Improving and monitoring the health impact of water, sanitation and hygiene interventions in developing countries

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Abbreviations

AFD  Agence Française de Développement
AFDB  African Development Bank
AFHEA  African Health Economics and Policy Association Conference
BAC  Before and After Control
BCTs  Behavior change techniques
BGR  German Federal Institute for Geosciences and Natural Resources
BMZ  German Federal Ministry for Economic Cooperation and Development
CBS  Community-Based Sanitation Framework
CHC  Community Health Clubs
CLTS  Community-Led Total Sanitation
DALY  Disability-Adjusted Life Years
DED  German Development Service
DFID  Department for International Development
DHS  Demographic and Health Surveys
DID  Difference in Differences
EHCP  Essential Health Care Program
FC  Financial cooperation
FOAM  Focus on Opportunity, Ability, and Motivation
GDWQ  Guidelines for Drinking-water Quality
GIS  Geographic Information Systems
GIZ/GTZ  German Society for International Cooperation
HIE  Health Impact Evaluation
HWTS  Household Water Treatment and Safe Storage
HWWS  Handwashing with Soap
IOB  Policy and Operations Evaluation Department of the Netherlands Ministry of Foreign Affairs
IWA  International Water Association
JMP  Joint Monitoring Program
KfW  German Development Bank
LFA  Logframe analysis
M&E  Monitoring and Evaluation
MDG  Millennium Development Goals
MICS  Multiple Indicator Cluster Survey (MICS)
O&M  Operation and Maintenance
ODA  Official Development Aid
ODF  Open Defecation Free
OECD  Organization for Economic Cooperation and Development
PCR  Polymerase Chain Reaction
PHA  National Rural Sanitation and Hygiene Promotion Programme
PHAST  Participatory Hygiene and Sanitation Transformation
POU  Point of use
PPP  Public private partnerships
PPPHW  Public-Private Partnership for Handwashing
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>QVZ</td>
<td>Quantifizierbares Versorgungsziel</td>
</tr>
<tr>
<td>RANAS</td>
<td>Risk, Attitudes, Norms, Abilities, Self-Regulation</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized control trial</td>
</tr>
<tr>
<td>SARAR</td>
<td>Self-esteem, Associative strengths, Resourcefulness, Action-planning and Responsibility</td>
</tr>
<tr>
<td>SHARE</td>
<td>Sanitation and Hygiene Applied Research for Equity</td>
</tr>
<tr>
<td>SNAPE</td>
<td>Service National d'Aménagement des Points d'Eau</td>
</tr>
<tr>
<td>SODIS</td>
<td>Solar Water Disinfection</td>
</tr>
<tr>
<td>SSHE</td>
<td>School Sanitation and Hygiene Education</td>
</tr>
<tr>
<td>STH</td>
<td>Soil transmitted helminthes STH</td>
</tr>
<tr>
<td>TC</td>
<td>German Technical Cooperation</td>
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<tr>
<td>UNICEF</td>
<td>United Nations Children's Fund</td>
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<tr>
<td>UNSGAB</td>
<td>United Nations Secretary General’s Advisory Board on Water &amp; Sanitation</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
</tr>
<tr>
<td>WASH</td>
<td>Water, Sanitation and Hygiene</td>
</tr>
<tr>
<td>WATSAN</td>
<td>Water and Sanitation</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<td>WSP</td>
<td>Water and Sanitation Program</td>
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<tr>
<td>WSRP</td>
<td>Water Sector Reform Program</td>
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<tr>
<td>WSS</td>
<td>Water Supply and Sanitation</td>
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<tr>
<td>WSUP</td>
<td>Water and Sanitation for the Urban Poor</td>
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</table>
Summary of Recommendations

Targeting and Strategies

1) In prioritizing projects, consideration should be given to the local conditions and the contributions of WASH aspects compared to each other, as well as compared to other sources of hazards to human health. Assessing which pathways are most relevant for disease transmission in a specific local setting could be a very useful basis for effective project planning.

2) It should be invested more into projects with the major objective to improve sanitation in combination with hygiene (also food hygiene).

3) Projects targeting water for public health outcomes should increase the focus on water quality improvements at point of use.

4) Projects targeting sanitation are probably more effective in (poor) urban settings.

5) The highest health impacts can be achieved in countries with low access to water and sanitation and high (diarrhea) disease burden.

6) Projects principally aimed at public water supply (i.e. and not water quality at the point of use, sanitation or hygiene) may achieve important non-health outcomes, especially time savings, but are unlikely to result in direct health outcomes.

7) Interventions should not attempt to address all possible pathways (e.g. water and sanitation and hygiene) at once: in particular water supply interventions are not demonstrably more effective when combined with sanitation and hygiene promotion.

Behavior change

8) Give a higher priority for behavior change measures during resource allocation, implementation and M&E.

9) Interventions should aim at use/behavior/compliance and therefore utilize evidence-based behavior change software.

10) Each WASH intervention includes several behaviors to be changed which all have to be taken into account.

11) Every hardware intervention (latrines, safe wells, handwashing stations) should be accompanied by evidence-based software (behavior change interventions) to assure the sustainable use of the hardware.

Monitoring and indicators

12) Projects should follow a systematic monitoring with standardized indicators across water, sanitation, and hygiene.
13) Self-reported diarrheal disease is an acceptable indicator of health outcomes, even though being affected by biases, if the recall period is not more than a week and sample sizes are large. However, given the complex pathogen chain, improvements in WASH might not always lead to a reduction in diarrhea incidence.

14) We therefore recommend that primary aim of monitoring should focus on the highest result within the project domain: adequate use of safe (and sole) drinking water and sanitation systems, management of child feces, effective hand washing practices, presence of soap, cleanliness of toilet facilities, and water quality (at source and point of use).

Knowledge gaps

1) Increase knowledge on effects of (various) improved sanitation systems
2) Increase knowledge on effects of improved hygiene behavior – apart from hand washing
3) How to achieve behavioral change at scale
4) Protocols for assessing relevant pathways
5) Protocols and knowledge on effects in schools and health centers
1 Introduction

One of the greatest health challenges in developing countries is the problem of inadequate water supply and sanitation. Even though great progress has been made in the last 20 years, diarrheal diseases are still the leading cause of child deaths in Africa and the second leading cause of child deaths globally (WHO 2008). Apart from diarrhea, inadequate WASH (water, sanitation and hygiene) also contributes to the morbidity and mortality burden from many other related diseases (see Section 2.2). Moreover, inadequate WASH and diarrheal disease are highly correlated with malnutrition and stunting.

Although the share of global aid going to WASH has diminished from 8 per cent in the mid-1990s to around 5.5 per cent today (OECD 2009), OECD data shows that the absolute ODA commitments to the water and sanitation sector have steadily grown over the last 30 years to around 8.8 billion US$ in 2011 (Anand, 2013). In 2011, Germany was together with Japan, the largest bilateral donor worldwide investing in improvements of drinking water and sanitation services (see Annex 1.1). German commitments in the WASH sector were 1.172 USD millions in 2011. (Anand, 2013), constituting 8 per cent of total German development cooperation and 21 per cent of total bilateral aid to the WASH sector.

The interventions of the development agencies are based on the hypothesis that by providing improved drinking water and sanitation facilities and hygiene education (=WASH) as well as by contributing to sector reforms and capacity development within WASH, the health status of the target groups will improve. However, despite substantial amounts of investments in the WASH sector, it is not clear if the expected health outcomes will be attained by current WASH interventions. Evaluations commissioned in 2010 and 2011 by the German Development Cooperation (Günther and Schipper 2011; Klasen, Lechtenfeld et al. 2011) showed that the intended health impacts of WASH interventions were not attained. As a result of these evaluations, many agencies recognize the necessity to review the causal chain, which assumes that projects for drinking water and sanitation contribute to better health of beneficiaries.

UN estimates show that while 66 per cent of global WASH aid is allocated to water, only 34 per cent is allocated to sanitation. (WHO/UN Water 2012). Of all funds 75 per cent are focused on the urban sector and 25 per cent on the rural sector (WHO/UN Water 2012), and about 62 per cent on large systems and 22 per cent on basic systems. Hygiene promotion accounts for only 1 per cent of all WASH expenditures (OECD 2012). In this context, it further has to be assessed if the current focus of funds allocation is justified with the ultimate objective to substantially increase the health impact of WASH development interventions.

The present study therefore aims to review the scientific evidence of the impact and cost effectiveness of past WASH interventions, to summarize lessons-learnt from past project experiences and evaluations of German Development Aid and other organizations, to assess potential indicators for better monitoring and management of WASH interventions with regard to health impacts, and to present tentative recommendations for future WASH interventions and studies needed to improve our understanding of the relationships between WASH interventions and health. These recommendations will focus on the following questions:
• What can be learned from scientific research and case-based experience of past development projects for future WASH programs?
• How should WASH programs be designed – given the current knowledge - to achieve maximum health impacts?
• How should WASH programs be monitored and evaluated to assess health impacts and achieve maximum organizational learning?

The main focus of the present study is on the impact of water, sanitation, and hygiene interventions on reducing the burden of disease caused by inadequate WASH. The impact of improved water and sanitation facilities on other outcomes such as for example time savings or education will not be considered in this study. Even broader issues relating to water security or water management are also not taken into account for this study on WASH and health.

The study is structured as follows:

In chapter 2 facts and figures about water quality, access and water related diseases worldwide are presented. Chapter 3 provides a framework of analysis for projects by presenting three conceptual models related to pathogen transmission, successful project implementation and a results model. In chapter 4 a selection of behavior change approaches is presented and discussed. In chapter 5 the principles of understanding and assessing indicators are presented. Chapter 6 assesses findings concerning the existing correlations between WASH and diarrheal diseases and malnutrition in four different sections (sanitation, hygiene, drinking water supply and quality): for each section the state of research and the measured results of scientific health impacts studies are presented, followed by a section on target behaviors and behavior change. Each section finishes by depicting existing indicators used to measure health impacts of WASH interventions which are assessed according to their validity and practicability. Chapter 6 concludes with a chapter on combined WASH interventions, cost-effectiveness studies and focus on specific target groups. Chapter 7 summarizes the lessons learnt from evaluations of the German Development Cooperation of WASH projects and Chapter 8 aims to give recommendations for future WASH projects and programs.

2 WASH and Health

To improve health outcomes, one of the major objectives of water supply, sanitation and hygiene interventions is to improve the drinking water quality and quantity of the target population with the ultimate objective to decrease water and food related diseases (see also Table 2.2 and Figure 3.1).

We therefore start with international set targets for adequate (in relation to health) water quality and quantities (per person and day), followed by a brief summary of WASH-related diseases and the disease burden they cause worldwide. We conclude this section with an overview of access to improved WASH infrastructure in developing countries— given that little is known about the water quality and quantity consumed in developing countries.

2.1 Water quality and quantity targets

Safe drinking water is defined in the Human Right to safe drinking water as “water free from micro-organisms, chemical substances and radiological hazards that constitute a threat to a person’s health” (UNGA 2010). However, the WHO GDWQ (2011) acknowledges that “100 % free” is not achievable, and that it is most effective to define the public health target to achieve. This can be done in terms of additional infections due to water (e.g. not more than $10^{-4}$ infections through
drinking-water) or – more accurately – in terms of disability-affected life years, i.e. DALY (e.g. not more than $10^{-5}$ DALY per person and year), which essentially are infection rates multiplied by a factor describing the severity or degree and duration of disability caused on average by infection. Once defined, such a health target can be “translated” to water quality targets which would allow the health target to be met. For many types of viruses this may well be as low as $10^{-5}$ per liter. Maximum limits related to microbial, chemical, radiological and aesthetic (taste, odor and appearance) quality are provided in the World Health Organization Guidelines for drinking-water quality that represent a reference point for the development of water quality standards by national public health authorities (WHO 2011). The WHO has set health-based guideline values for 90 different chemicals and it is neither feasible nor desirable to monitor all of these. By far the greatest threat to public health comes from microbial contamination caused by inadequate sanitation, hygiene practices and/or water supply. Thousands of different pathogens could cause disease related to unsafe water, but the vast majority of disease burden is related to fecal pathogens. Of the different possible fecal indicator species, *E. coli* or thermotolerant coliforms provide a high level of confidence as they are in many cases present in large numbers in polluted waters (WHO 2011, p. 148). While WHO recommends a guideline value that *E. coli* must not be detectable in any 100 ml sample of drinking water, the WHO Guidelines for Drinking-water Quality (GDWQ) discuss in depth the importance of setting targets on the basis of the respective local setting. Therefore less strict interim targets may be appropriate e.g. for drinking-water if the assessment has shown e.g. direct exposure to fecal material and thus sanitation to be the higher priority.

According to WHO (2003), the absolute minimum human need of water uptake to maintain human survival in moderate climatic conditions and average activity level is defined as approximately 3 liters of clean water per day. The basic requirements are estimated at about 7.5 liters a day based on the requirements for lactating women engaged in moderate physical activity, in above-average temperatures including hydration, food preparation and basic hygiene (WHO 2003). The WHO specifies four levels of water quantity with corresponding health impacts (see Table 2.1). For intermediate water access 50 liters per person are recommended, of which 25 liters per person per day are needed for drinking and basic hygiene practices with an additional 15 liters per person per day for bathing and 10 liters per person per day for cooking. With approximately 100 liters per person per day, all domestic needs could be met. The Special Rapporteur for the Human Right to Drinking Water and Sanitation acknowledges these benchmarks (UNGA 2010), but notes that it isn’t possible to set global standards for quantity, since water requirements depend heavily on local conditions and cultural practices. For example, domestic water requirements increase with urbanization and private water connections (White et al., 1972). India uses a norm of 40 liters per person per day for rural areas, whereas it sets a norm of 70 (without underground sewerage) and 125 liters (with underground sewerage) per person in urban areas. One reason is the hypothesis that in rural areas other water sources can be used for bathing and washing clothes (Meinzen-Dick and Appasamy 2002).

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1 This approach is similar to the target used for setting guideline values for carcinogenic chemicals, i.e. not more than one additional cancer case in a population of one million.

2 The water amount for cooking does not include the water required for food growing.
Table 2.1: Water access level and quantity of water collected (WHO 2011)

<table>
<thead>
<tr>
<th>Service level</th>
<th>Distance/time</th>
<th>Likely volumes of water collected</th>
<th>Public health risk from poor hygiene</th>
</tr>
</thead>
<tbody>
<tr>
<td>No access</td>
<td>More than 1 km/30 min round-trip</td>
<td>Very low: 5 liters per capita per day</td>
<td>Very high: Hygiene practice compromised Basic consumption may be compromised</td>
</tr>
<tr>
<td>Basic access</td>
<td>Within 1 km/within 30 min round-trip</td>
<td>Approximately 20 liters per capita per day on average</td>
<td>High: Hygiene may be compromised Laundry may occur off-plot</td>
</tr>
<tr>
<td>Intermediate access</td>
<td>Water provided on-plot through at least one tap (yard level)</td>
<td>Approximately 50 liters per capita per day on average</td>
<td>Low: Hygiene should not be compromised Laundry likely to occur on-plot</td>
</tr>
<tr>
<td>Optimal access</td>
<td>Supply of water through multiple taps within the house</td>
<td>100-200 liters per capita per day on average</td>
<td>Very low: Hygiene should not be compromised Laundry will occur on-plot</td>
</tr>
</tbody>
</table>

Source: (WHO 2003) modified

Moreover, as shown in Table 2.1, water quantities are related to water distance and/or collection times. According to WHO (2011), clean water should be available from a source within 1 kilometer of the users dwelling and the (roundtrip) collection time should not exceed 30 minutes. The time frame of 30 minutes is based on the assumption that the time to collect water is negatively related with water consumption. According to (Cairncross and Feachem 1993), once the time to collect water exceeds five minutes or 100m from the house, the water quantity collected decreases. If the water collection time exceeds 30 minutes the household does not collect enough water to maintain adequate hygienic conditions for low health risks (see Table 2.1). However, note that this relationship – even though being cited for almost 20 years now – is not based on scientific evidence but based on the authors’ experience in the field and more evidence is certainly needed here.

2.2 Classification of WASH diseases

Diseases related to WASH are classified according to four main transmission pathways (White, Bradley et al. 1972; Mara and Feachem 1999; Prüss, Kay et al. 2002; Cairncross and Valdmanis 2006). See also Appendix 2.1. The first group is **water-borne diseases**, where the pathogen is ingested while drinking water or bathing. Water-borne diseases are caused by the direct ingestion of pathogens due to contaminated drinking and washing/bathing water. The most important water-borne diseases are diarrhea, dysenteries, typhoid fever, and arsenicosis. It is important to note that although water can be a very significant exposure route for pathogens, many of the diseases that may be water-borne are also transmitted by other routes including person-to-person contact, contamination of fingers, food, fomites, field crops, or flies (Cairncross and Feachem 1993). Depending on the circumstances, these routes may be more important than water related transmission (WHO 2011). This also means that water-borne diseases are possibly also transmitted via water-washed (or water-scarce) routes: **water-washed (or water-scarce) diseases** are due to inadequate hygiene conditions as a result of lack of water and/or inadequate hygiene practices. They are susceptible to control by hygiene
improvements. The most important water-washed diseases are scabies, trachoma and respiratory infections. Third, \textit{water-based} diseases refer to transmission by means of an aquatic invertebrate host and are contact diseases. The transmission occurs through direct contact of the body with contaminated water. The most important water based diseases is schistosomiasis. Last, \textit{water-vector} diseases involve an insect vector that breeds in or near to water, frequently a mosquito. The most important diseases are malaria, dengue fever, lymphatic filariasis and onchocerciasis (river blindness). Additionally, \textit{soil-transmitted helminthes} (including the human hookworms) are not directly associated with unimproved water but with unimproved sanitation and the use of excreta in agriculture. Soil-transmitted helminthes are transmitted via human excreta and mature in soil before becoming infectious. See also Appendix 2.1 for an overview of diseases.

\section*{2.3 The Disease Burden of inadequate WASH}

According to the WHO, 10\% of the total burden of disease\textsuperscript{3} or 6\% of all deaths are related to diseases related to unimproved water, sanitation and hygiene (WHO 2008). Among children the burden is even higher: 25\% of child deaths and 22\% of the disease burden among children are attributable to WASH related diseases (Prüss-Üstün, Bos et al. 2008, see also Annex 2.2). This does not include respiratory infections that are also likely to be linked to insufficient hygiene, but which cannot be linked quantitatively to WASH (Prüss-Üstün, Bos et al. 2008, see also Annex 2.2). In an attempt to estimate the total burden of WASH, Günther and Fink (2013) estimate that between 0.6-1.7 million child deaths per year could be prevented with improved access to water and sanitation.

However, according to recent estimates from the significant Global Burden of Disease 2010 study (Lim, Vos et al. 2012) only 1\% of the total burden of disease worldwide and 4\% of the disease burden among children worldwide are attributable to WASH. They estimate that unimproved sanitation is “only” the 8\textsuperscript{th} leading risk factor and water the 10\textsuperscript{th} leading risk factor of the child disease burden in the developing world (headed by undernutrition, household air population, and vitamin, iron and zinc deficiencies). For the entire population water and sanitation rank between the 10\textsuperscript{th} and 20\textsuperscript{th} risk-factor for different regions of sub-Saharan Africa and between the 20\textsuperscript{th} and 30\textsuperscript{th} risk factor for other developing countries.\textsuperscript{4}

There are stark differences between these estimates, calculated by the Institute for Health Metrics and Evaluation (IHME) and the WHO figures. Part of the difference can be explained by development: IHME estimates are for 2010 while WHO are from 2004. It is widely agreed that the last decade has seen tremendous health gains. IHME estimates that between 1990 and 2010, annual deaths from diarrheal disease dropped by over 40\%, from 2.5 to 1.4 million. These estimates are consistent with the WHO estimate of 1.8 million deaths in 2004.

However, while WHO considers that 88\% of diarrheal deaths can be attributed to unsafe water, sanitation and hygiene, the IHME estimates that unimproved water and sanitation are responsible

\textsuperscript{3} The global burden of disease is measured in DALYs (disability-adjusted life years). DALY is a measure of overall disease burden expressed as the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. DALY combines thus in one measure the time lived with disability and the time lost due to premature mortality. One DALY can be thought of as one lost year of “healthy” life. The burden of disease is thus the sum of theses DALYs across the population.

\textsuperscript{4} For more detailed statistics see: http://www.healthmetricsandevaluation.org/gbd/visualizations
for only 23% of diarrheal deaths in 2010. This difference is due more to differing methodologies than development. For example, IHME acknowledges that poor hygiene has been linked with disease burden, but does not include poor hygiene in its estimates because of the paucity of nationally representative data. Furthermore, IHME considers that there is no disease burden from use of ‘improved’ water and sanitation facilities, although it is widely recognized that improved water sources frequently deliver unsafe drinking water, especially in developing countries.

Another difference is that WHO considers children to bear the great majority of the health burden (83% of diarrheal deaths), while IHME calculations predict that under-5 children account for only 47% of diarrheal deaths. The cause for this disparity is not clear, but is not simply due to trends over time, as IHME estimates that even in 1990 children constituted only 66% of the total diarrheal deaths.

Because of these methodological differences, WHO and other leading public health institutes have not endorsed the IHME figures, and WHO is in the process of updating its own burden of disease estimates. For the remainder of this report, we will refer exclusively to the WHO estimates.

Diseases related to water, sanitation and hygiene also disproportionally affect the poor of developing countries. The reasons are on the one hand a higher pollution of their environments, and on the other hand a lack of access to WASH and health services (Prüss, Kay et al. 2002).

Moreover, despite the numerous diseases related to unimproved WASH, the WASH disease burden – measured in disability-adjusted life years (DALYs, see also chapter 3.1) or deaths – is mainly caused by diarrheal diseases, being responsible for 40% of all WASH diseases (see Table 2.2). The incidence of diarrheal diseases varies greatly with the seasons and children’s age. Incidence is highest in the first two years of life and declines as the children become older (Kosek, Bern et al. 2003). In 2010 each child in the developing world has experienced an average of 2.9 episodes of diarrhea per year (Fischer Walker, Perin et al. 2012). Moreover, Fink et. al. (2013) have shown that children living in the slums of towns show the highest incidence of diarrhea (compared with children living in rural areas and cities).

The second leading disease related to inadequate WASH, with about 25%, is malnutrition (see Table 2.2). Moreover, diarrheal diseases and undernutrition are highly correlated and influence each other: on the one hand, children who are malnourished or have impaired immunity are most at risk of life-threatening diarrhea. Therefore, children who die from diarrhea often suffer from underlying malnutrition, which had made them more vulnerable to diarrhea. On the other hand, diarrhea is a major cause of malnutrition in children under five years old (WHO / UNICEF 2009).

Moreover, recently conducted research has shown that a major reason for undernutrition is tropical enteropathy caused by fecal bacteria, which also causes diarrhea (Humphrey 2009). Tropical enteropathy affects almost all children in the developing world and leads to a reduced absorption of nutrients. Children in rural Bangladesh living in ‘clean’ households (defined as having relatively good quality drinking water, improved sanitation, and handwashing facilities) were not only found to have less diarrhea than children in ‘unclean’ households, but also showed better growth over a three-year period, resulting in 22% lower stunting prevalence compared to children from unclean households.

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5 Impaired immunity means the inability of a body to fend off common infections from bacteria, fungi, virus and malignancy, which a normal immune response would have prevented.
Significant differences were also seen in enteropathy, as measured by intestinal absorption of a dual sugar solution (Lin, Arnold et al. 2013). This means that the effect of inadequate sanitation and hygiene conditions on children’s growth is underestimated, because it was only modeled through diarrhea in the past and not through tropical enteropathy (Humphrey 2009).
Table 2.2: The 10 leading diseases related to inadequate WASH

<table>
<thead>
<tr>
<th>Disease</th>
<th>Water</th>
<th>DALYs (millions)</th>
<th>% of total DALYs</th>
<th>DALYs (millions) Children</th>
<th>Deaths (millions)</th>
<th>Deaths (millions) Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrheal diseases</td>
<td>-borne -washed</td>
<td>52.5</td>
<td>38.6</td>
<td>48.8</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Consequences of Malnutrition</td>
<td>-borne -washed</td>
<td>28.5</td>
<td>21.0</td>
<td>28.4</td>
<td>0.79</td>
<td>0.79</td>
</tr>
<tr>
<td>Malaria</td>
<td>-vector</td>
<td>19.2</td>
<td>14.2</td>
<td>18.0</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Drowning^6</td>
<td>-related</td>
<td>7.9</td>
<td>5.8</td>
<td>3.8</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Malnutrition^7</td>
<td>-borne -washed</td>
<td>7.1</td>
<td>5.2</td>
<td>7.1</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Lymphatic filariasis</td>
<td>-vector</td>
<td>3.8</td>
<td>2.8</td>
<td>1.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Intestinal nematode infections</td>
<td>soil transmitted</td>
<td>2.9</td>
<td>2.2</td>
<td>2.9</td>
<td>0.01</td>
<td>0.08</td>
</tr>
<tr>
<td>Trachoma</td>
<td>-washed</td>
<td>2.3</td>
<td>1.7</td>
<td>0.01</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>-based</td>
<td>1.7</td>
<td>1.3</td>
<td>0.6</td>
<td>0.01</td>
<td>0</td>
</tr>
<tr>
<td>Dengue</td>
<td>-vector</td>
<td>0.6</td>
<td>0.4</td>
<td>0.5</td>
<td>18</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: Prüss-Ustün et al. (2008) modified

Given the importance of diarrhea for WASH related diseases and for the global disease burden in general, and particular for children, previous studies on the impact of WASH as well as this study focus on the impact of WASH on diarrhea diseases on children to measure health impacts of water, sanitation and hygiene.

2.4 Infrastructure monitored

Even though the international community has a pretty good understanding and discussion about the level and trend of WASH-related diseases (see Sections 2.2 and 2.3), little is known about levels of drinking water quality and quantity in developing countries (see Section 2.1). This is despite the fact that most donors and development organizations^8 base their definitions of acceptable water and sanitation on the Human Rights to Water and Sanitation elaborated by the United Nations (see Annex 2.3), which starts with water/sanitation availability (quantity) and quality. An example for the German Development Cooperation is given in Annex 2.4.

In practice most often - because of operational, cost, and data availability reasons - the simple definition by the Joint Monitoring Program (JMP) is used to monitor international progress in access to improved water and sanitation and to evaluate program and/or project success (see Annex 2.5). This simplified indicator counts the number or the share of people who report using improved water and sanitation infrastructure. Use of improved water and sanitation facilities may not be adequate to improve health outcomes because of multiple possible pathogen transmission pathways (see Figures 4.1 and 4.2 in the following chapter). Improved water and sanitation facilities are just the beginning of a long way to prevent pathogen transmission from feces to the human body (see Figure 4.1).

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^6 WHO classifies drowning as water-related disease. Drowning is defined by WHO as the process of experiencing respiratory impairment from submersion/immersion in liquid (WHO 2012).

^7 Only protein-energy malnutrition (PEM) is considered (WHO, 2008a).

^8 The definitions for appropriate water access of World Bank, AfDB, GIZ/KfW, AFD, DFID and USAID were screened.
Moreover, indicators based solely on use of improved facilities completely neglect hygiene behavior which up to date is not monitored systematically – neither nationally nor internationally. We therefore propose a list of intermediate indicators to monitor WASH interventions in Section 5, which go beyond access to facilities.

Figure 2.3: Access to improved water and sanitation

![Figure 2.3: Access to improved water and sanitation](image)

Source: UNICEF (2013)

However, monitoring results on infrastructure shows (Figure 2.3) that even though considerable progress has been made world-wide in the last 20 years, sub-Saharan Africa and Southern Asia are considerably lacking behind, especially for sanitation.

3 Conceptual Models

In this chapter we build a framework to systematically analyze the impact and constraining factors of WASH projects and programs. First we describe how pathogens are transmitted to humans through various pathways from feces to water and food consumption and where WASH interventions can interrupt these transmission pathways. Then we set up a conceptual model about how health outcomes can be achieved. Finally we show a result model that links the pathogen transmission and health behavior models within the results framework.

3.1 Pathogen transmission

The causal loop diagram in Figure 3.1 illustrates the major nodes and links of pathogen transmission and the respective WASH interventions to prevent pathogen transmission. The contamination of drinking water and food with feces with a negative impact on human health is fostered by three transmission channels: ground- and surface water, fingers and fields/ flies. The direct contamination route from feces to food by application of manure as fertilizer is covered in the part “fields and flies”. Interventions preventing pathogen transmission comprise sanitation, water interventions at source water, interventions at point of use (POU) and hygiene education and/or promotion that intervene at very different points along the transmission chain.

The point of pathogen transmission has important implications for the (cost-) effectiveness of these interventions in relation to health. As shown in Figure 3.1 improved sanitation cuts off many pathogen transmission pathways (4 out of 7), whereas improved hygiene with regard to water and food consumption prevents most of pathogen transmission (5 out of 7). In contrast, water
interventions – and especially interventions at the water source – only interrupt very few
transmission pathways (1 or 2 out of 7).

Even if sanitation and hygiene interventions could be most effective in theory, their practical
implementation might often be more difficult than water supply interventions. Using improved
sanitation and changing hygiene behavior require a higher behavioral change of the target
population so that sustainable use is difficult to achieve, and is more context specific. WASH
interventions can only be successful in interrupting transmission channels if they are functioning and
lead to a behavioral change of the target population that in turn depends on the right mix of
hardware and software components and on taking into account the adequate context. This is
illustrated by the box at the top of Figure 3.1, which is described in more detail in Section 3.2.

From a purely theoretical pathogen transmission perspective, sanitation and hygiene therefore seem
to be more promising for improving health than water supply interventions. However, in spite of the
general observations gleaned from the literature and presented in chapter 2.3, for the specific
setting of a project this information does not elucidate which transmission pathway is the locally
most important in terms of pathogen ingestion. The WHO Guidelines for Drinking-water Quality
(2011) discuss the importance of assessing which pathways are most relevant for disease
transmission in a specific local setting. Such assessments could be a very useful basis for effective
project planning of the German Development Cooperation.

In order to improve public health through improvements in the fields of drinking-water, sanitation
and hygiene, health-based targets should be set taking into account the public health situation and
the contribution of these fields to disease in order to assist in determining interventions (WHO
2011). Such targets may be

- Health outcome targets (e.g. tolerable burdens of disease);
- Which translate to water quality targets (e.g. guideline values for chemical hazards);
- Which translate to performance targets or (e.g. log reductions of specified pathogens);
- Which may translate to specified technology targets (e.g. application of defined treatment
  processes).

As part of target setting, WASH as well as other possible sources to health hazards and the relevance
of their contributions need to be considered as a basis for prioritization. In order to quantify and
compare the burden of disease associated with different water-related hazards, WHO uses the
concept of disability-adjusted life years (DALYs) as a metric to evaluate public health priority settings.
This principle weights each health impact in terms of severity within the range of 0 (good health) to 1
(death). The weighting is then multiplied by duration of the effect and the number of people
affected. For prioritizing interventions on a local level, data on local relevance of hazard sources
should be considered wherever available (including for example already existing coverage of
improved drinking water supplies and improved sanitation).

Understanding the relative importance of the various transmission pathways for the specific local
setting and the implementation effectiveness of WASH interventions for the specific context is crucial
when designing WASH projects/programs. A promising approach to deal with this problem which is
worth further investigations are spot-check observations (Ruel and Arimond, 2002; Webb, Stein, et
al., 2006). This method can be used for a fast assessment of WASH related hygiene practices in
households: (i) disposal of human feces, (ii) use and protection of water sources, (iii) water and
personal hygiene, (iv) food preparation and storage, and (v) domestic and environmental hygiene. With the indices of these observations, the magnitude of the infection pathways can be represented. Calculating a regression analysis on health outcomes using these indices would unfold the relative impact of each pathway on health. Doing this for a local context this would reveal the most infectious pathway(s) to be tackled.

Figure 3.1: Transmission routes of pathogens and interventions points of WASH

Source: Modified after (Prüss, Kay et al. 2002; Waddington, Snilstveit et al. 2009))

3.2 Successful implementation – behavior and context
In this chapter we describe the elements of an intervention process with the objective to interrupt pathogen transmission for improved health. These elements have to be taken into account for effective project and/or program implementation. Often, WASH projects and/or programs expect to have an impact simply by installing an (hardware) intervention. With the implementation model depicted in Figure 3.2 we try to create awareness for all the elements of a program which influence success. This implementation model is an extension of the one proposed by (Waddington, Snilstveit et al. 2009).
Most water and sanitation interventions begin by (partly) providing hardware and (not always) software. Hardware might be safe wells, latrines or only latrine slabs, or hand-washing stations. Software relates for example to instructions on the use and maintenance of the hardware, health risk information, or skills based hygiene promotion. The successful delivery of hardware and software depends decisively on the implementation process. Obviously, if a water pump is not installed properly it will not function and if the instructions for use cannot be decoded people will not be able to use it. The implementation process is even more decisive for software implementation. Without an extensive pre-testing and an intensive training of promoters hygiene education for example will have no effect. Software interventions are used to introduce a new behavior in a population e.g. using (exclusively) a point-of-use-system for drinking water treatment or performing hand-washing with soap. Before behavior change can take place behavioral determinants have to change. Behavioral determinants are for example knowledge, perceived health risks, costs and benefits, or social norms. So far implementers often assume that increasing knowledge is enough to change behavior which in most cases is inappropriate. The provision of hardware, the change in regulations, as well as changing social norms has to be represented in the mindsets of the people to cause behavior change. If the mindset of a person has not changed then his or her behavior will not change at all. Research has shown that in all WASH sectors behavior is determined by several factors (see (Kamara Tumwebazea, Garimoi Orach et al. 2012) for sanitation; Curtis et al., 2009 for handwashing; (Tamas in press) for drinking water). Behavioral models which take into account the variety of behavioral determinants are described in chapter 4.

An absolute but obvious precondition for success of any WASH intervention is behavioral change and change in social norms. If people do not use the new safe water wells, do not go to the newly
installed latrines, and do not use the delivered handwashing stations – then there will be no health impact at all. Moreover there might be inadequate use, e.g. drinking water from safe wells as well as from unsafe wells, using toilets but not cleaning them, washing hands only after eating but not in key situations (after going to toilet, before eating).

All the so far mentioned elements of development programs are influenced by the specific context in the project area. The environmental context restricts the intervention possibilities insofar as for example arsenic-free deep tubewells are not suitable in coastal areas of Bangladesh because they will contain salty water; likewise water flush toilets are not appropriate in arid regions of Mauritania. The legal context defines through rules and regulations what kind of interventions are allowed and which not. The cultural context should be taken into account for the intervention implementation because there may be cultural particularities which delimit behavior change. For example, in some cultures handling with feces is culturally outlawed and therefore emptying latrines will never be performed by these people. The economic context defines mainly the price of an intervention. In some countries the price for a ventilated toilet is reasonable compared to the mean income whereas in other countries this might be not at all the case. The social context poses constraints about what people in a society are used to do and what they are not used to do which impairs how easy or difficult it is to implement an intervention. For example if people in a target population already boil their water for drinking purposes then it will be much easier to introduce a new additional water disinfection method as for example the time and energy saving method of Solar Water Disinfection (SODIS).

Project and programs which aim at interrupting pathogen transmission simply by providing hard- and user-software are shortsighted if not accompanied by behavior change interventions and they will not be successful.

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**BOX: Scale of Interventions**

Interventions can be designed and applied at different scales, with implications for indicators and monitoring.

**Population.**

Large-scale interventions may target entire populations, at national or sub-national scales. Classic examples are national immunization campaigns, but social marketing and more commercial approaches also apply at large scales. Behavior change interventions at large scale typically rely on mass media because of the high cost of individual contacts.

*In Ghana, a national handwashing campaign was launched in 2003. Formative research identified ‘disgust based on nurture’ as a significant motivator, and a series of TV and radio spots graphically showed how poor handwashing practice could lead to direct ingestion of feces. The mass media campaign reached 83% of the target population and had a significant impact on reported handwashing (Scott, Schmidt et al. 2008).*

**Sub-populations and Institutions.**

Interventions may be targeted at particularly vulnerable sub-populations, or groups particularly amenable to behavior change. WASH interventions in schools have the potential to build healthy habits for lifetime. Health centers, markets, transport centers, prisons, refugee camps, and workplaces also represent settings where WASH interventions may be particularly important.
The Fit for Schools program in the Philippines has targeted improving handwashing and tooth brushing practice among school children by using a skills-based approach, introducing these hygiene activities as a daily practice as part of the school routine. The pilot project rapidly expanded to cover 2.5 million children within four years, due to strong support from the Philippines government. One year into the program, children in intervention schools showed a significantly higher increase in Body-Mass Index (BMI), and lower prevalence of soil-transmitted helminths (though this may be an artifact of much higher worm burden in the control group at baseline). (Monse, Benzian et al. 2013)

People living with HIV/AIDS are particularly vulnerable to water-borne diseases. Household filters and safe storage systems were distributed to HIV-positive mothers within the catchment area of two health clinics in rural Zambia. Water quality, diarrheal disease, and child mortality were all improved in intervention areas (Peletz, Simunyama et al. 2012).

**Community.**
Sanitation interventions are particularly suited for the community scale, since poor sanitation by one household may lead to community scale contamination, impacting the health of others who have good sanitation practices. Research suggests that at least 75% of community members should practice good sanitation in order for health benefits to be realized. Furthermore, interventions may also target improving drinking-water supply at the community level. Drinking-water supplies at the community level can benefit from sanitation interventions particularly in rural areas where both are often located close to each other, and poor sanitation may pollute drinking-water. Community approaches are possible but more difficult in urban areas, where social interlinkages are more transient.

WaterAid Bangladesh targeted over 16,000 communities with CLTS between 2004 and 2009. An evaluation in 12 communities which were declared Open Defecation Free found that the percentage of households with a toilet ranged from 72% to 93%. Sharing of toilets was common, especially among the poor (Evans, Colin et al. 2009).

**Household.** Handwashing is a personal behavior performed in private. Interventions to increase handwashing with soap therefore often aim for behavioral change at the household and individual level. Menstrual hygiene, household water storage and handling, and household water treatment are further examples of household-targeted interventions.

In peri-urban settlements of Karachi, Pakistan, 900 households were randomly assigned to handwashing with soap, handwashing with antibacterial soap, or control. Households were visited weekly for 1 year to promote regular handwashing habits. Soap consumption tripled in the two intervention areas, and both diarrheal disease and pneumonia were reduced by approximately 50% (Luby, Agboatwalla et al. 2005).

### 3.3 Results model
Many development agencies have followed a general logical framework in their international programming. The original logframe analysis (LFA) approach was developed for USAID in the 1960s, and became widespread among development agencies. Central to the LFA is the concept of hierarchies of objectives, beginning with Inputs, which when accomplished yield in turn Activities, Outputs, Purposes (or Outcomes or Objectives) and Goals (or Impacts). At each stage in the framework, objectively verifiable indicators and means of verification are defined. Logframe Analysis
implies a linear causality chain which is not always consistent with reality. Many development partners (e.g. Norad, SIDA) have switched to the related but less rigid ‘Results Based Management’ framework. In 2012 GIZ adopted a new Results Model, which defines Results as “intended, positive changes in a state of affairs or behavior.” Results are mapped in relation to each other, forming a complex, non-linear Results Framework. Within the Results Framework, a project or program identifies the highest-level Result as the Objective. Setting the Objective is a strategic process done through dialogue with partners and commissioning parties. Within the Results Framework, the acting agency and its partners can select an appropriate strategic option within a change process to realize the desired Objective and its proximate Results. Outputs are delivered to achieve the defined Results, while Activities are the contributions made to producing Outputs (see Figure 3.3)

Figure 3.3: Results Model

A combination of the pathogen transmission model (Figure 3.1) and the WASH implementation model (Figure 3.2) can be translated into the language of the Results Framework (figure 3.3). One possible portrayal is shown in Figure 3.4.
In this depiction, improved health depends on reduced pathogen exposure, which in turn depends on safe water, safe food, and clean hands. Programs and projects which target health improvements would have to make a strategic decision as to which Result in this framework could be set as the Objective, for which the project/program would be held responsible. Indicators should be established for both the Objective and the proximate Results targeted.

4 Behavior change approaches

In this chapter a selection of approaches to behavior change representing different points-of-entry are shortly described and evaluated using several criteria. First, it is denoted which behavior change techniques the approach is supposed to use. Second, the way these techniques are thought to work is specified. This is not possible for all approaches because the majority does not make assumptions about how their techniques work. Third, the existing evidence about how effectively these approaches can change behavior (not health!) is delineated. Fourth, the pros and cons of the approaches are discussed with regard to several criteria. Fifth, it is noticed what kind of expenses are to be taken into account when implementing an approach. Many of the here discussed approaches (and many more) can be found in an excellent overview by (Peal, Evans et al. 2010).

4.1 Participatory approaches

Participatory Hygiene and Sanitation Transformation (PHAST) (Biran 2008)
Participatory Hygiene and Sanitation Transformation is designed to promote hygiene behaviors, sanitation improvements and community management of water and sanitation facilities using specifically developed participatory techniques. This approach works on the premise that as
communities gain awareness of their water, sanitation and hygiene situation through participatory activities, they are empowered to develop and carry out their own plans to improve this situation. The plans adopted may include both construction and management of new physical facilities as well as safer individual and collective behaviors.

**Behavior change techniques (BCTs):** Seven steps: problem identification, problem analysis, planning for solutions, selecting options, planning for new facilities and behavior change, planning for monitoring and evaluation, participatory evaluation.

**Functioning of BCTs:** A series of pictures depicting local situations is used. Images must be adapted to the local context to avoid stereotypes. Groups of people are asked to say how these relate to the local situation (but never to themselves directly) and what they would need to do to solve the problems that they have identified.

**Evidence of effectiveness:** There is no evidence about the effectiveness with respect to hygiene behavior change or a reduction in diarrheal disease.

**Pros and Cons:** Rewarding for both the community members and community workers, by involving the communities in their project planning and implementation through participatory techniques. Experienced community workers are needed to take part in the training which may feel compelled to use the participatory tools in a directive manner. The community workers must be closely monitored and corrective action taken if the approach is excessively directive in practice. The approach requires an intensive management structure. This is feasible in smaller “grass-roots” projects but becomes problematic if the aim is to “go to scale” at a programmatic or national level because the tools are relatively time intensive in their use. The approach requires that the beneficiary communities are available to go through the participatory exercises; this may be seen as a burden if not properly discussed with the community beforehand.

**Expenses:** Requires in-depth training of community workers in participatory techniques. On average two weeks are needed for this training to be completed, to be followed up by regular refresher courses. This has budget implications.

**Self-esteem, Associative strengths, Resourcefulness, Action-planning and Responsibility (SARAR) (Harnmeijer 1994)**

This is an education/training methodology for working with stakeholders at different levels to engage their creative capacities in planning, problem solving and evaluation. The objective of the approach is not to teach a specific message or subject matter, but to stimulate the learners to think through problems for themselves and to help them to develop their own analytic, creative and planning abilities.

**Behavior change techniques (BCTs):** Self-esteem: a sense of self-worth as a person as well as a valuable resource for development. Associative strength: the capacity to define and work toward a common vision through mutual respect, trust, and collaborative effort. Resourcefulness: the capacity to visualize new solutions to problems even against the odds, and the willingness to be challenged and take risks. Action planning: combining critical thinking and creativity to come up with new, effective, and reality-based plans in which each participant has a useful and fulfilling role. Responsibility: for follow-through until the commitments made are fully discharged and the hoped-for benefits achieved.

**Functioning of BCTs:** Not stated.

**Evidence of effectiveness:** Insufficient data to evaluate the overall impact.
Pros and Cons: This approach is directed toward whole communities, but it has proved to be useful in giving special attention to population groups, such as women. Problems have arisen when the use of SARAR techniques has been considered an end in itself, rather than a means to support the development and implementation of project activities. This problem can occur when SARAR activities are not linked to concrete follow-up activities. The effectiveness of SARAR, can also be limited by a general resistance—usually by higher level managers and decision-makers.

Expenses: Training-of-trainers, materials development and production and community based workshops and follow-up.

4.2 Community approaches

Community-Led Total Sanitation (CLTS) (Kar 2003) (Chambers 2009)

The CLTS approach is a participatory approach. It advocates changes in institutional attitudes and the need to draw on intense local mobilization to enable the people to analyze their sanitation situation and bring about collective decision-making to stop open defecation. Once people are convinced about the need of sanitation they will build their own toilet according to the available resources. The householders assess the water and sanitation situation in their community as well as the location of open defecation sites. Through further participatory exercises, discussions and awareness raising activities a community plan is developed to stop open defecation, and promote more hygienic individual behavior, and trigger for self-financed household sanitation and latrine usage at community level.

Behavior change techniques (BCTs): Focus group discussions; transect walks; mapping of open defecation sites; ‘shit’ calculations (that calculate the total weight of feces produced and circulating in the community).

Functioning of BCTs: generate a sense of ‘disgust’ and ‘shame’ amongst the community.

Evidence of effectiveness: It remains unclear how Open-Defecation-Free is defined in practice. Sustainability of latrine usage and of installed facilities is not yet clear and may be limited where access to appropriate affordable products and services is poor; the impacts on health remain unknown.

Pros and Cons: This does not need sanitation subsidies or service delivery from external agencies; people are encouraged to change their hygiene behaviors without prescribing how they should do it; requires effective and skilled facilitation as well as good verification systems; questions remain on the relevance of CLTS for urban and large settlements.

Expenses: Only training and transportation of facilitators.

Community Health Clubs (CHC) (Waterkeyn and Cairncross 2005)

The Community Health Club approach is a broad-based health education and behavior change approach that addresses a range of relevant disease prevention and health topics, including sanitation and hygiene behaviors. The approach promotes a ‘culture of health’ where healthy living becomes highly valued, bringing about behavior change, through peer pressure and the desire to conform. The main activity is the holding of regular meetings to learn about and discuss ways to improve household and community hygiene. The meetings are properly-organized sessions with a registered membership. It draws on participatory and adult group learning theory and methods, but adds the additional structure and cohesion of club formation and membership which provides greater discipline, mutual support, social interaction, and motivation. Weekly meetings of CHCs can
address up to 30 different topics over a six month period. Each session encourages active participation from all registered members and requires members to practice their new learning at home through weekly recommended practices, or homework assignments. These can involve simple changes such as covering stored water or using a ladle, to more demanding challenges like building latrines or protecting communal water sources. These progressive changes are achieved by encouraging dialogue amongst CHC members, resulting in changes to community norms and values associated with WASH practices. All members are issued with a membership card, listing the topics covered and recommended practices to be implemented at home. This is important as it provides a sense of identity and encourages others to join, setting learning targets, and acting as a monitoring tool for program managers. Attendance certificates are awarded to each member who completes all health promotion sessions and implements all the recommended practices at home, which confer important social status and are a huge incentive for members to complete the health promotion phase.

**Behavior change techniques (BCTs):** presenting health related information; giving advice; songs; club member cards; mutual control; certificate

**Functioning of BCTs:** proved: knowledge about how diarrhea is contracted; unproved but argued: social pressure; feeling of belonging; personal experience; self-efficacy

**Evidence of effectiveness:** in several journal articles the evident difference between members and non-members in several hygiene related outcomes (e.g. covered water, hand wash facility, pot rack, and clean swept yard) is reported. However, these studies mainly rely on spot-check data (device existing yes/no) meaning that the actual behavior is not measured. It also remains unclear who joins the clubs and who does not and nothing is reported about drop-outs.

**Pros and Cons:** CHC is an effective approach for many hygiene related issues and others (e.g. nutrition gardening). With 20 sessions over 6 months it is quite time-consuming.

**Expenses:** Promoters initiate, conduct and supervise the clubs. Each club can have even more than 100 members. It is reported that 1 promoter can coach 3 clubs.

### 4.3 Social marketing approaches

**PPPHW (Public-Private Partnership for Handwashing) (Saadé, Bateman et al. 2001)**

This approach aims to raise awareness, to enhance political commitment and resource allocation for hygiene, to offer a route to a coordinated national program, combining them all under one umbrella. PPPHW also uses high-profile and up-to-date methodologies to change the hygiene behavior which consistently demonstrates the greatest potential impact on overall public health, especially handwashing with soap. PPPHWs aim to implement large scale handwashing interventions. The approach targets those most at risk (mothers, children and the poor) across the whole population. PPPHWs enable private industry and the public sector to work together (with other partners) to develop programs to promote handwashing.

**Behavior change techniques (BCTs):** To make market handwashing successfully, the following four questions about consumers must be answered: What are the risk practices? Who carries out risk practices? What drivers, habits, and/or environment can change behavior? How do people communicate?

**Functioning of BCTs:** Not stated.

**Evidence of effectiveness:** (Saadé, Bateman et al. 2001) report that the PPP in Guatemala resulted in ten percent of mothers in Guatemala moving out of the ‘inadequate’ handwashing group into either
the ‘intermediate’ or ‘optimal’ group. Increased soap sales and institutional change was reported by soap companies and their subsidiaries, although details are difficult to come by.

Pros and Cons: Makes use of the professionalism and marketing expertise of the private sector, in particular in the design and implementation of the mass-media component of the handwashing campaign.

Expenses: It takes time and effort putting together a country team with the commitment, resources, and skills to set up, supports, and run a national handwashing program.

4.4 Psychological approaches

Focus on Opportunity, Ability, and Motivation (FOAM/ SaniFOAM) (Coombes and Devine 2010)

This approach is a conceptual framework designed to help in the development, monitoring, and evaluation of handwashing or sanitation behavior change programs. The FOAM and SaniFOAM frameworks have been developed to help practitioners a) analyzing the results of available formative studies; b) informing the design of new research; c) prioritizing the behaviors to be changed and the populations to be targeted; d) understanding and considering the range of factors that influence a particular behavior; e) focusing and prioritizing interventions on particular factors for behavior change; f) improving the effectiveness of interventions aimed at changing the behavior, and g) identifying the appropriate indicators to monitor. Both FOAM and SaniFOAM identify the factors that influence the behaviors and classify these under the categories of Opportunity, Ability and Motivation. The F in FOAM and SaniFOAM stands for Focus which serves to identify what target population and behavior is being analyzed.

Behavior change techniques (BCTs): within an operational matrix communication techniques are developed according to the marketing mix (product, price, place, promotion).

Functioning of BCTs: it is supposed that opportunity, ability and motivation are the factors steering behavior. Opportunity: Does an Individual have the resources to perform behavior? (Access/availability. Product attributes. Social norms). Ability: Is the Individual capable of performing the particular behavior? (Knowledge. Social support). Motivation: Does the Individual Want to Perform the Behavior? (Belief and attitudes. Outcome expectations, threats, intentions)

Evidence of effectiveness: no data

Pros and Cons: The big progress of FOAM is that this approach uses psychological knowledge to understand behavior change which in our understanding is the only way to generate behavior change purposely. However, this knowledge is not consequently derived from psychological theory meaning that many behavioral factors are not proved to influence behavior. Additionally it is not defined how to measure the determinants.

Expenses: unknown because no reports are available.

The RANAS Model (R(isk), A(ttitudes), N(orms), A(bilities), and S(elf-Regulation) (Mosler, 2012)

The RANAS is a procedure which yields evidence based behavior change. This is realized by operating the following steps: 1) conducting a baseline survey on behaviors and behavioral determinants; 2) using these data identifying the determinants to be targeted; 3) selecting behavior change techniques which change the determinants to be targeted; 4) pretesting several behavior change strategies; 5) conducting a follow-up survey; and 6) using these data to determine the most effective behavior change strategies. The RANAS behavior change model builds on several theories of behavior change from environmental and health psychology. The model describes behavioral factors, which have to be favorable to the new behavior in order for it to emerge. These factors can neatly be
classified into the following five factor blocks: risk factors entail perceived vulnerability and perceived severity of contracting a disease, and factual knowledge about the possibility of being affected by a potential contamination; attitude factors comprise instrumental beliefs about costs and benefits of the targeted behavior, as well as affective beliefs, i.e. feelings arising when thinking about the behavior; norm factors include different social influences: descriptive norms (behaviors typically performed by others), injunctive norms (behaviors typically approved or disapproved by others) and personal norms (personal standards, what should be done); ability factors indicate people’s perception to perform a behavior (perceived behavioral control) and the confidence in one’s ability to organize and manage the targeted behavior (self-efficacy); self-regulation factors help to manage conflicting goals and distracting cues when intending to implement and maintain a certain behavior. Important determinants are commitment, perceived habit and remembering the behavior. By comparing people who have sustainably adopted the new practice with those not showing the behavior, the key factors which influence behavior change can be determined, and used to refine and optimize promotion activities.

*Behavior change techniques (BCTs)*: the RANAS provides a table which depicts the behavior change techniques which alter specific behavioral determinants.

*Functioning of BCTs*: the techniques assigned to specific behavioral determinants designed to alter these determinants.

*Evidence of effectiveness*: many publications are available which corroborate the functioning and sustainable effectiveness of the approach (e.g. 65% of new users of solar water disinfection in Zimbabwe are found to have drinking water bottles in the sun even 18 months after the last intervention).

*Pros and Cons*: the approach is using psychological knowledge on behavior change which is based on a multitude of scientific studies. However, at a first glance the approach appears to be expensive and time-consuming but the result is a verified and viable behavior change strategy.

*Expenses*: Team of interviewers (6-12 depending on the required sample size) and a field coordinator to conduct the surveys; costs of behavior change strategies depend on behaviors to be tackled.

### 4.5 School focused approaches

**“Fit for school” - Essential Health Care Program (EHCP) (Monse, Benzian et al. 2013)**

The Essential Health Care Program (EHCP) uses simple, evidence-based interventions that are delivered at low cost in elementary schools: Daily supervised handwashing with soap; daily supervised tooth brushing with fluoride toothpaste; bi-annual deworming. The EHCP started on a limited scale with pilot programs supported by German Development Cooperation in 2003, and received its formal launch in 2008. In the first full year of the program, school year 2008/09, the number of children covered was 633,000 and reached just under 1.5 million children in 24 provinces and three cities by school year 2010/11. A longitudinal health outcome study has shown positive health effects after one year of program implementation: 20% less underweight children, 30% less absenteeism, 40% less infections from decayed teeth, and 50% less heavy worm infections compared to schools employing traditional health education.

*Behavior change techniques (BCTs)*: supervised handwashing with soap; daily supervised tooth brushing

*Functioning of BCTs*: the techniques are commanded by the teacher

*Evidence of effectiveness*: it can be assumed that the pupils perform the behavior when commanded by the teacher. There are no reports about lack of compliance or about pupils refusing to participate.
Pros and Cons: when the infrastructure is already installed it seems to be relatively easy to implement the approach. However, in some countries it could be challenging to make the teachers perform the required behaviors with their pupils.

Expenses: infrastructure (multiple distribution system with taps for drinking water); soap, toothbrushes; toothpaste; de-worming medicine.

Water, Sanitation and Hygiene (WASH) in schools / School Sanitation and Hygiene Education (SSHE) (Shordt 2008) (Bolt, Shordt et al. 2006)

WASH in Schools includes both hardware and the software aspects to bring about changes in hygiene behavior of students. The hardware is defined as ‘the total package of sanitary conditions and facilities available in and around the school compound’. The software is defined as ‘the activities aiming to promote conditions at school and practices of school staff and children that help to prevent water and sanitation-related diseases’. The approach recognizes that a schoolchild educated to the benefits of sanitation and good hygiene behavior is a conduit for carrying those messages far beyond the school walls, bringing lasting improvement not only to his or her health and wellbeing, but also to that of the family and the wider community.

Behavior change techniques (BCTs): Activities are: 1) Training of Trainers or orientation of community and parent groups such as the school management committee, parent teacher association leaders and self-help groups; 2) Parents (rich and poor), teachers and community groups decide on the technology, designs and payments using participatory tools; 3) Preparation of water and sanitation (WATSAN) plan and community contribution; 4) Training of teachers and head teachers, providing lesson plans and materials; 5) Classroom teaching; 6) Active school clubs with children in school, home and community; 7) Construction of water points, toilets and urinals, handwashing and water storage.

Functioning of BCTs: the activities are organized by the teacher

Evidence of effectiveness: also here it can be assumed that the pupils perform the behavior when commanded by the teacher. There are no reports about lack of compliance or about pupils refusing to participate.

Pros and Cons: direct health benefit to pupils. If the infrastructure is already installed it seems to be relatively easy to implement the approach.

Expenses: infrastructure water points, toilets and urinals, handwashing and water storage; activities in and outside the school.

4.6 Which behavior change approach to choose?

Many of the displayed approaches show that there is a mutual interaction between infrastructure and behavior change interventions: supply of infrastructure without behavior change will not render adequate use and applying behavior change interventions without supply of infrastructure may even not have any effect.

Behavior change implicates a change in the mindset of the individual who should change his or her behavior. If one agrees on this statement then these approaches are effective and efficient which reflect on the mindsets of the individuals of the target populations. The behavioral determinants in the mindsets have to be identified, containing social, cultural, and environmental factors. The differential values of these determinants between performers and non-performers of the target behavior have to be measured, and the differing determinants to be tackled purposefully. Therefore approaches which use psychology in a systematic way should be used. Keipp (2012, KFW, KC Wasser
und Abfallwirtschaft) mentions that the failure of many health promotion activities comes from the unsystematic attention to psychological behavior determinants. Having said this we recommend to use psychological founded approaches like FOAM or RANAS, whereas only the RANAS approach contains a stringent methodology of measuring behavioral determinants and accordingly deriving behavior change techniques.

The weaknesses of the psychological approaches are that they do not explicitly tackle a whole community and are not using a participative methodology. However, for the community-wide and participatory approaches we do not know how the mechanics of behavior change are. Most of them are “somehow” effective but this raises questions whether all elements of these approaches are necessary, which elements are especially effective, and which ones might have a slight or even big contrary effect (e.g. shame in CLTS).

The social marketing approaches also use in some way psychology but in a way focused on the purchasing of a product. This approach might be successful when a product has to be acquired but it does not make sense when an everyday behavior has to be introduced which has to overcome continuously occurring barriers and simply has to be remembered in the right time.

From the presented approaches only the CHC and possibly CLTS are explicitly skill-based approaches. From psychological research we know that approaches where people experience the performance of a new behavior are more successful than approaches which work only with information because they enhance self-efficacy (Albarracin, Gilette et al. 2005). The RANAS method is more sophisticated in this regard because herein it is determined by evidence which intervention should be applied. If people simply do not know how they can contract diarrhea then they need information but if they do not have a hand washing station then they should be trained on constructing one. The question is not skill-based versus information-based approach but the approach should always be driven by evidence otherwise it will not satisfy the needs of the population.

The school oriented approaches do not need psychology because the pupils are more or less forced to perform the requested behaviors. However, to convince the teachers to conduct the health program the psychological approaches could be of merit. To expect that there is a transfer of behaviors conducted in the schools to the household and communities without any additional measures is naïve. In many cultures the distance between children and parents is so big that adults will never accept innovations from children. Also the transformation of new behaviors is simply impossible if the households do not have or do not want to purchase needed infrastructure (e.g. handwashing station). So far there is no evidence showing this transfer and obviously additional promotion activities will be needed.

At the end of this chapter we want to point out that in the paper of (Keipp 2012) nearly all necessary steps to conduct effective behavior change campaigns are mentioned and we highly recommend to adhere to the method described there.

5 Understanding and assessing indicators

5.1 Definitions

This section will build up a basic vocabulary relating to indicators: what are desirable characteristics of indicators, what different classes of indicators are there, and how are different indicators suitable for different purposes?
Different indicators, and possibly different classes of indicators, will be appropriate for the different stages along the Results Chain. In many cases, the different stages in a result chain correspond to (WHO 1983; WHO 2002)

A. **Inputs and activities**. Support provided directly by the project/program. These should always be monitored internally using the Yearly Plan of Operation, which tracks funds disbursed, human resources provided, trainings held, etc.

B. **Output indicators (functioning of new systems)**. New hardware should be physically operational following the inputs, and responsibilities for operation and maintenance of the hardware systems should be assigned. Institutions responsible for hygiene and sanitation promotion should be functional. This level is typically not the objective of an intervention, and indicators at this level measure the direct achievements of the project (e.g. number of latrines built, number of hygiene promotion meetings held). These outputs should be sufficient to provide ‘access’ to the target populations.

C. **Use indicators**, which measure the correct use of new systems (outputs) by target populations. Adopting new WASH practices is a behavioral change that does not necessarily take place, even when hardware and software systems are functioning. Monitoring at this level is critical, and may be achieved through internal and external mechanisms. Indicators of usage may include a mixture of self-reports and observation, and should incorporate social and psychological considerations. For sustained use, indicators of system maintenance are essential. In many cases this level will correspond to the objective in the Results Framework.

D. **Impact indicators**, measuring impacts such as health improvements or time savings on target populations. Impacts are often outside the project/program domain, and may depend on results which are not supported by the intervention. For example, an intervention focusing on safe water may have no impact on diarrheal disease if safe food and clean hands (see Figure 3.1) are not also achieved. Other impacts may fall entirely within the intervention domain, for example a sanitation intervention to reduce ascariasis, or a water supply intervention to improve drinking water quality, to reduce risk factors or to increase time savings.

At any stage within the results framework, appropriate indicators must be selected. Indicators may directly describe result of interest, but often the result is hard to measure directly, especially if the result is a use or behavior. In some cases proxy use indicators can be used: for example, the presence of soap in various places within a household is used as a proxy for handwashing behavior.

The objective reality can never be completely measured. Instead, indicators give approximate indications of reality. Descriptive indicators may be either reported (by users or by institutions such as governments) or observed (by surveyors, or by surveillance authorities).

In selecting indicators, program planners need to balance the quality of the indicator against the cost and effort required to collect information. These criteria can be defined as (Porta 2008):

- **Validity**: “an expression of the degree to which a measurement measures what it purports to measure.” Does the indicator reflect well the real status of the Result which we want to affect?
• **Efficiency**: “the effects or end results achieved in relation to the effort expended in terms of money, resources, and time.” Are the necessary human and financial resources available, and do the benefits justify their use?

Validity can be assessed by comparing results obtained from an indicator against an accepted reference or ‘gold standard’ which is assumed to reflect the actual status. Indicator validation is normally done at a research level rather than in program monitoring. Since ‘gold standard’ data may be difficult to come by, another approach to assessing validity is to correlate the indicator against higher-level results assumed to be causally linked to the result under consideration. For example: indicators of handwashing may be considered valid when they correlate with less diarrheal disease. This approach is acceptable, as long as possibly confounding factors are accounted for in the analysis. Households with good handwashing practice might have other characteristics which are responsible for lower disease burden (e.g. better sanitation, water quality, or food quality).

Indicators with greater validity tend to be more expensive (though some expensive indicators are not valid). ‘Validity’ of indicators is more or less scale-independent, whereas ‘efficiency’ is highly contextual, and depends largely on the scale of the project and budget. A rule of thumb is that from 5-10% of the overall budget should be used for monitoring and evaluation, the amount of funding available will determine which indicators are efficient for a particular project or program.

The 5-10% budgetary allocation should always include routine monitoring of inputs and activities, functioning of new systems (hardware and software, and use of systems by target populations. Impact assessments should target the objective within the results framework, and are normally done periodically, every 1-2 years. For large, well-funded interventions, relatively expensive data collection systems may be justified, while for smaller projects on a tight budget, more basic indicators are appropriate. Some cost savings can be realized by tapping into existing data (e.g. JMP surveys), but such sources are unlikely to have the statistical power necessary for project monitoring or evaluation. Whether large or small, projects should avoid invalid indicators – bad data can be worse than no data at all.

### 5.2 Methods for conducting impact assessments

#### 5.2.1 Study designs

Assessing the impacts of interventions is an epidemiologic task, and one which can be met using several different study designs (WSUP/SHARE 2011). Epidemiologic studies fall into two classes: **experimental** and **observational** (Dicker, Coronado et al. 2012).

- In **experimental studies** the investigator determines which individuals or groups receive a treatment (e.g. a WASH intervention) and then tracks those individuals or communities over time to see the impact of the treatment. By comparing against a control group which didn’t receive the intervention, the significance of the impact can be calculated. A classic experimental study is the randomized control trial (RCT), in which individuals or groups are randomly assigned to intervention or control treatments.

- In **observational studies** the investigator observes the exposure and health impacts within the study population, but doesn’t determine which groups receive treatments. It’s possible for WASH interventions to be implemented with an experimental methodology, but in practice it is very difficult politically and ethically to randomly assign individuals or areas to treatment...
and control. This challenge can in principle be overcome using a **stepped wedge** design (e.g. Gruber, Reygadas et al. 2013), in which the intervention is extended in stages to all individuals or groups, with those that have not yet received the intervention serving as controls. However, in practice this is difficult to implement and most interventions are assessed using an observational approach.

Observational studies can be further broken down into three main types:

- **Cohort studies** involve repeat measures of a single set of individuals over a period of time. Exposure assessments are made at the beginning of the study, and impacts are measured during follow-up surveys, both for exposed and non-exposed populations. The same individuals can be monitored a few times or many times, depending on the health outcome. Cohort studies are similar to **ecological studies**, in which data from whole populations is analyzed and tracked over time. The difference is that in ecological studies, data are analyzed at the population, not the individual, level. For example, skin cancer rates amongst different districts could be compared to average arsenic levels in drinking water, without knowing the individual exposure histories.

- **Case-control studies** are those in which a number of individuals having a disease (cases) are enrolled, and compared to people without the disease (controls). The characteristics of the two groups are then compared to find any significant differences. The main challenge in case-control studies is of defining an appropriate control group.

- **Cross-sectional studies** involve collection of data on exposure and health outcomes at the same time. These studies are logistically easier than cohort or case-control studies, and are excellent for determining the prevalence of a disease in a population (the proportion of people having the disease at a given time). However, it is difficult in such studies to measure disease incidence (the number of new cases per person per year).

- Cross-sectional surveys made before and after an intervention, with a suitable control group, constitute a **‘Before and After Control’ (BAC) study**. With this design, a **Difference in Differences (DID)** analysis can be made to see how much of the change can be attributed to the intervention (WSUP/SHARE 2011), and how much is due to general trends in the population (‘secular trends’). In this design the intervention is not extended to the control population. Challenges here are in finding a well-matched control population which does not receive the intervention, including from other programs.

In any of these methodologies, the units of sampling should correspond to the intervention, and may be individuals, families, households, villages, institutions, or even larger groups. It is of critical importance to select samples which are representative of the target population.

Single measurements of diarrheal disease are of limited value in that disease may follow important seasonal trends, and can be heavily affected by short-term events. This shortcoming can be addressed through a longitudinal study design, in which households are visited repeatedly (e.g. from 6-12 times over a full year). This approach, commonly applied in RCTs or cohort studies, allows robust measures both of the disease burden and its variability in time (WSUP/SHARE 2011). For longitudinal studies, a full year of baseline surveillance should be completed before the intervention is made, followed by another year of surveillance (which could be done in different households) after the intervention.
However, it may not be possible to spend a year collecting baseline information (though such time might well be spent concurrently planning an intervention, recruiting and training facilitators, etc.). In this case, a single survey before and after the intervention (i.e. cross-sectional studies) can be considered. For example, rather than visiting 250 people 12 times in a longitudinal study, a cross-sectional study would survey 3,000 people one time. See (Schmidt, Arnold et al. 2011) for a detailed analysis of monitoring strategies, including recommendations on frequency of monitoring for different purposes. If the parameter of interest shows greater variability in space than over time, a cross-sectional survey will give better estimates of parameters than a longitudinal study (Markovitz, Goldstick et al. 2012).

Regardless of the methodology followed, it is critical to survey a non-intervention population in the same way as the intervention group – without a control group it is impossible to say if any observed changes are due to the intervention, or to a broader change in societal practices unrelated to the intervention, or even due simply to the monitoring process itself. The mere act of surveying a population frequently results in lowered reports of diarrheal disease in subsequent surveys (Zwane, Zinman et al. 2011); this can be explained in part by ‘survey fatigue’ both on the part of the respondents and the interviewers. Examination of studies with robust monitoring of control populations often shows impressive reductions in intervention areas, but equally impressive reductions in control areas (e.g. Figure 5.2.1). A DID analysis would reveal that in this case the intervention was not responsible for the otherwise impressive decline in diarrhea episodes.

Figure 5.2.1: Percent of diarrhea episodes per total number of observations in intervention and control groups, by surveillance visit (N=3240), (Jain, Sahanoon et al. 2010)

Which methodology is appropriate for assessing the impact of supported interventions? It is unlikely that such interventions will be conducted in a fully experimental way, such as an RCT with randomly
assigned treatments. Observational studies are more practical and appropriate for large-scale programs. In particular, cross-sectional studies made before and after interventions are relatively easy to implement and can yield the desired information about changes in behaviors and disease prevalence. The BAC methodology is likely to be an efficient and effective methodology for evaluating impacts of supported programs. However, cross-sectional studies should not be used where the goal of the intervention is to reduce disease incidence, rather than prevalence: longitudinal surveys would be a better tool in this case.

5.2.2 Indicators for diarrheal disease

Different WASH-related diseases have been presented in Section 2.2 and 2.3. This review focuses on diarrheal disease because of its public health importance. Measurement of diarrheal disease is complex since a wide variety of pathogens can cause disease. Furthermore, many people infected with these pathogens are either non-symptomatic or consider chronic loose stools as a chronic condition (especially for small children). Definitions of diarrheal disease incidence and prevalence are included in Annex 4.2.

Enteropathy, or damage to the intestinal lining, is proposed as a root cause of both diarrhea and malnutrition (Hunter, Zmirou-Navier et al. 2009), and can be quantified through dual sugar absorption studies (e.g. Campbell, McPhail et al. 2004). The Bill and Melinda Gates Foundation is supporting research in Bangladesh, Kenya, and Zimbabwe to explore links between WASH and enteropathy. Findings from Bangladesh indicate that objective indicators of enteropathy correlate strongly with water, sanitation and hygiene measures, as well as with self-reported diarrheal disease and malnutrition (Lin, Arnold et al. 2013). This measure has the promise of high validity, but is still in development and is not yet effective for project monitoring purposes.

Because of the close links between diarrhea and malnutrition, some nutrition-related indicators have been proposed as proxy indicators of diarrheal disease. Anthropometric indicators of malnutrition (Mid-Upper Arm Circumference, Weight-for-Age Z scores) typically are not impacted by WASH interventions, but short-term changes in these indicators, particularly Weight-for-Age Z-scores, show promise as valid proxy indicators of diarrheal disease (Schmidt, Boisson et al. 2010). Weight for age is inexpensive to collect, and more objective than self-reported diarrheal disease.

The most commonly collected indicator is self-reported diarrhea (or caregiver reports of diarrhea cases among household children). Household respondents are typically asked if they (or household children) have had any cases of diarrheal disease within a given recall period. Since diarrheal disease mainly affects children, studies can gain power by limiting the questions to diarrheal disease among children. This type of community surveillance is relatively effective: surveys are not very expensive. However, the validity of survey responses is questionable. First, when long recall periods (greater than 7 days) are used, respondents are less able to give accurate, factual replies (Arnold, Galiani et al. 2013). Shorter recall periods are less prone to bias, but significantly increase the sample size. For most purposes, a 7-day recall should be recommended.

Second, when respondents are enrolled in an intervention, they may be aware that the intervention is designed to reduce diarrheal disease, and so may (intentionally or unintentionally) under-report disease. In a highly controlled randomized control trial, this kind of courtesy bias would be minimized by blinding both the respondent and the interviewer to the intervention. However, many WASH interventions are inherently difficult or impossible to blind (there are no placebos for toilets or
Outside the WASH sector, unblinded studies of subjectively measured outcomes typically show effects about 25% larger than blinded studies (Wood, Egger et al. 2008), so reductions in self-reported diarrheal disease in the range of 20-50% could be largely or completely due to bias. The few studies available which have blinded household water treatment have found no significant impact on diarrhea (Schmidt and Cairncross 2009).

Bias can be managed by using more objectively measured outcomes – this is possible for some WASH-related diseases (e.g. helminth egg counts in feces) but remains a challenge for diarrheal disease. Stool samples can be collected and analyzed for specific pathogens linked with diarrhea (e.g. Kotloff, Blackwelder et al. 2012) but this is highly expensive and not effective for routine monitoring and evaluation. Furthermore, many people pass the pathogen in feces without exhibiting clinical symptoms, so the validity of individual pathogen measurements for predicting diarrheal disease is questionable.

An alternative to community surveillance is administrative surveillance (e.g. health clinic records), either of self-reported or clinically verified disease. If health clinic records are available, the cost of data collection is very low. However, the validity is limited: most cases of diarrheal disease are treated locally and never reach health clinics, though in urban areas clinic-based rates are higher than in rural areas. Administrative surveillance is thus of limited use in tracking ordinary diarrheal disease, but could be valid and efficient for more severe outcomes such as dysentery or cholera (Feikin, Olack et al. 2011).

For most evaluation purposes, the self-reported prevalence of diarrheal disease with a 7-day recall period is likely to be a suitable indicator. If a BAC methodology is chosen, it is important to conduct the baseline and follow-up studies during the same season, since diarrheal disease often follows seasonal cycles. If possible, the surveys could be made in the same season as other available surveys which report disease, such as DHS or MICS, to facilitate comparison with these other sources of data. If the intervention lasts multiple years, it is recommended to conduct interim annual impact surveys, which may be smaller in scope, to learn if interventions are starting to have the desired effects. Such interim information can inform project adjustments and course corrections if needed.

Evaluations should measure the impacts on health outcomes, but even more importantly should measure the impacts on the proximate causes of health outcomes: water, sanitation, and hygiene practices amongst the target populations. That is, monitoring of impacts should be supported by monitoring of outcomes. The following chapter reviews the relationship between sanitation, hygiene, and drinking water practices and disease, focusing primarily on diarrheal disease. For each target behavior, interventions and potential indicators are reviewed critically.
6.1 Sanitation

6.1.1 Interventions and impacts for sanitation: State of research

Almost all existing studies on the effectiveness of sanitation focus on the impact of the use of improved sanitation on diarrhea and/or nutritional status of children. Little evidence is available for other health outcomes. These studies have been summarized in several meta-studies showing that improvements in sanitation infrastructure can reduce the transmission of pathogens that cause WASH related diseases.

It has also been argued, that the reduction in WASH related diseases depends strongly on the level of sanitation within the targeted community (Eisenberg, Scott et al. 2007); (Esrey 1996; Gundry, Wright et al. 2004). Bateman and Smith (1991) purport that for maximum health impact; a majority of about 75% of households in a community should be using improved sanitation. WHO / UNICEF 2009 even

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There is an important risk of bias when using self-reported diseases or symptoms used as indicators in household surveys (compare chapter 6.2.3):

- The subjective evaluation of how disease frequency changed after receiving treatment (improvements, no change, or deterioration) is often heavily biased. Implausible answers have been noted by the evaluation team in Yemen.
- People tend to respond with the answer interviewers are waiting for. For example, they will automatically declare a decrease in diseases if they are connected to water pipe.
- Higher hygiene awareness is associated with higher reported incidence of malaria and diarrhea (presumably as the result of better knowledge) (IOB 2008).
- Self-reported illness is partly determined by the individual “recognition” of illness or the affordability of health care, often leading to underreporting by the poor, especially for common illnesses.
- Respondents may not be aware of the disease incidence among other household members.
- There is a risk of bias associated with inadequate recall periods – e.g. recall periods (4 weeks and 10 years in Benin for banal events as diarrhea). Depending on the nature of the disease, even relatively long recall periods can be appropriate (E.g. hepatitis). But for relatively frequent and benign diseases, short recall periods are necessary to avoid recall bias (see chapter 4.2).
claims that in order to significantly reduce diarrheal diseases transmission the entire community needs to stop open defecation and recommend a participatory total community sanitation approach by using peer pressure (Kar 2003; WHO / UNICEF 2009). Even though the approach has been implemented in various countries, with increasing sanitation access rates, no rigorous study comparing the health effect of the total community sanitation approach with other sanitation interventions exist. The only study we know of is Cameron et al. (2013) who study the impact of a total community led sanitation approach in India (but not in comparison to other approaches). They find that the program leads to a diarrhea reduction of 30% but cannot rule out that this decrease was driven by differences in drinking water and hand washing behavior.

It has also been argued that health benefits of sanitation are likely to be greater in densely populated urban areas, where open defecation leads to gross fecal pollution of entire neighborhoods. In contrast, open defecation in rural settings is often conducted at some distance from households (Cairncross and Valdmanis 2006). In fact, in rural settings use of unclean latrines close to the household may even increase disease burden compared to open defecation (Opryszko, Majeed et al. 2010). However, few studies exist which distinguishes between rural and urban areas. The only study we know of is Günther and Fink (2010) which show a slightly higher impact of sanitation infrastructure on diarrhea in urban areas in comparison to rural areas; no differences were found for mortality. But certainly more studies are needed here.

(Esrey, Potash et al. 1991; Esrey 1996) identified in a literature review 30 studies from a variety of different countries that examined the impact of sanitation on disease transmission. The high quality studies of this literature review reported a reduction of diarrhea morbidity by 36 per cent with improved sanitation infrastructure as well as increases in weight among both urban and rural children. A recent meta-analysis analyzing the effect of household and public latrines on health found that diarrheal disease was reduced by 32 per cent (Fewtrell, Prüss-Ústün et al. 2007). Waddington et al. (2009) studied in a meta-analysis the effectiveness of sewer connection and latrine provision on child diarrhea morbidity and found a reduction by 37 per cent. (Günther and Fink 2013) and (Fink, Günther et al. 2011) studied the differences between flush toilets and improved pit latrines with regard to their effect on child health across more than 40 developing countries. Access to improved sanitation was associated with lower mortality, a lower risk of child diarrhea, and a lower risk of mild or severe stunting. Their results show that the highest health benefits are found for private sewer connection. Children in households with access to private flush toilets have 13 per cent lower risk of suffering from diarrhea, 27 per cent lower risk of being stunted, and 23 per cent lower mortality risks. The reduction in diarrhea, stunting, and mortality for improved latrines is only 8, 12, and 3 per cent, respectively (Günther and Fink 2013). None of the studies have demonstrated that shared sanitation is less effective in improving health outcomes than private sanitation.

It is important to note that – in contrast to water supply studies – very few studies on the impact of sanitation infrastructure on health exist. Meta-studies are based on only between two to eight studies (in contrast to up to 22 studies for water supply interventions). Moreover, all evidence is based on observational studies, with a general lower scientific quality than (experimental) studies on water supply and or treatment. Published randomized trials on the impact of toilet provision on child growth or diarrhea are almost completely lacking (Humphrey 2009). The estimated impact of
sanitation infrastructure on health therefore varies largely - with diarrhea reduction between 10 and 37 percent – and is also likely to be overestimated.

Table 6.1: Examples of sanitation related impact studies and their measured health effects

<table>
<thead>
<tr>
<th>Reference</th>
<th>Approach/Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caincross et al. 2010</td>
<td>Impact of on-site sanitation on diarrhea</td>
<td>Diarrhea reduced by 20-51%</td>
</tr>
<tr>
<td>(Fink, Günther et al. 2011)</td>
<td>Impact of private sewer connection and private latrine provision on child diarrhea, stunting and child mortality</td>
<td>Sewer connection: 13 per cent lower risk of diarrhea, 27 per cent lower risk of stunting, 23 per cent lower risk of mortality Improved latrine: 8 per cent reduction in diarrhea, 12 per cent reduction in stunting, 3 per cent lower child mortality.</td>
</tr>
<tr>
<td>(Waddington, Snistveit et al. 2009)</td>
<td>Impact of sewer connection and latrine provision on child diarrhea</td>
<td>Diarrhea reduced by 37 per cent.</td>
</tr>
<tr>
<td>(Fewtrell, Prüss-Ustün et al. 2007)</td>
<td>Impact of public or household latrines on child diarrheaal</td>
<td>Diarrhea reduced by 32 per cent.</td>
</tr>
<tr>
<td>(Esrey, Potash et al. 1991)</td>
<td>Impact of human excreta disposal on ascariasis, diarrheal diseases, dracunculiasis, hookworm infection, schistosomiasis and trachoma.</td>
<td>Diarrhea reduced by 36 per cent.</td>
</tr>
</tbody>
</table>

6.1.2 Target behaviors and behavior change for sanitation
As depicted in the conceptual model about health outcomes in chapter 3.2 intervention hardware and software should induce change in behavioral determinants and hence behavior change. Therefore in this chapter we first display the kind of behaviors to be changed, then discuss the behavioral determinants with regard to sanitation, and then delineate the literature about behavior change approaches in this sector.

The behaviors to be changed or to be achieved with regard to proper sanitation are the following:

- open defecation: defecation on the open ground should be eliminated
- constructing or purchasing toilets: appropriate toilets have to be built either by doing the work by the users or by paying for construction
- inappropriate toilet use: toilet users should deposit their excrements in the designated spot
- cleaning: toilet cleaning has to be done either by the users or by paying a cleaning service
- emptying or paying for service: toilets in densely inhabited urban and peri-urban settlements and without connection to a sewer system have to be emptied regularly and the sludge has to be disposed or reused safely
- proper hygiene, especially hand-washing behavior after using and/or cleaning the toilet

There are only very few studies which work out the behavioral determinants of sanitation. For the case of Benin, Jenkins and Curtis (Jenkins and Curtis 2005) identified as main motivations for toilet installation two prestige drives: to affiliate with the urban elite, and to express new experiences and lifestyles, as well as two well-being drives: family health and safety, and convenience and comfort.

For the same country, Gross and Günther (2013) find different results: they don’t find that prestige is important, but that health and safety (especially at night) are the main drivers for installing a latrine, and that lack of resources is the main factor preventing the installation of a latrine. (Jenkins and Scott 2007) stated that the choice to install a toilet in Ghana is conditioned by appropriate
opportunities to build, related to product choices, cost, building services, soil conditions, and access to good technical information and support.

A behavior change approach which has the potential to generate rural demand for sanitation is the “Community Health Clubs” (CHC) approach (see chapter 4.2). (Waterkeyn and Cairncross 2005) report from Zimbabwe that with CHC latrine coverage rose to 43% contrasted to 2% in the control area. Another approach which seems to be useful in preventing open defecation is “Community-Led Total Sanitation” (CLTS) (see chapter 4.2). (Sah and Negussie 2009) report experiences from rural Ethiopia and rural Tanzania that within three months 93% of the households had constructed latrines as compared to 44% who had latrines before. (Pattanayak, Blitstein et al. 2007) conducted a study in Orissa, India which used as sanitation intervention subsidies and shaming from the CLTS approach. They indicate that latrine ownership did not increase in control villages but increased in intervention villages from 6% to 32%.

Summarizing it has to be stated that many of the relevant sanitation behaviors are not researched so far and only for toilet installation we know some of the behavioral determinants. For the avoidance of open defecation CHC and CLTS seem to be valuable interventions although it is not known which behavioral determinants are changed and whether there are counter effects as for example social ostracism (see Bartram, Charles et al. 2012).

**6.1.3 Indicators for sanitation**

GIZ defines seven criteria which are required for access to safe sanitation (GIZ 2012).

“A person is counted as having access to sanitation if he or she uses a toilet that:

- Is shared by family members (usually about 6 persons per household) or is a shared toilet within or nearby the plot (usually shared by no more than five families or up to 30 persons), or is a community toilet in high density low-income areas serving approx. 25 users per cubicle (and is less than 300 meter away from the household and takes less than 20 minutes to use (round trip));
- Is accessible at all times (7 days, 24 hours);
- Is embedded in a functioning sanitation system (excreta from the toilet is collected, stored, transported, treated and disposed or reused in a manner which minimizes contact between human excreta and humans or animals, is not hazardous to human health and not detrimental to the environment;
- Is regulated and monitored in terms of quality, minimum technical standards and tariff;
- Is combined with access to hand-washing facilities in case of community toilets;
- Together with costs for water are preferably not exceeding 5 per cent of monthly household income;
- Is providing privacy and is culturally acceptable in terms of separation of males and females and provision of anal washing if required.

These criteria lead naturally to indicators which should be monitored in projects and programs targeting sanitation as an objective or result, in the results model (Section 3.3). A description of 14
selected sanitation indicators related to these criteria, labeled S1 through S14 follows. Indicators are reviewed to assess their validity and efficiency.

Some aspects of access are important but not directly related to health outcomes (e.g. travel time to latrines). The aspects of sanitation which directly impact on health are those specifically related to separation of feces from the environments. Four indicators have been shown to have strong links with diarrheal disease, and some evidence shows that these indicators can also reduce other diseases related to fecal pathogens (e.g. other fecal-oral diseases, trachoma, soil-transmitted helminthes). It is noteworthy that none of these are output indicators (e.g. number of facilities constructed, access to facilities) – all are related to behavior and use of outputs, i.e. outcomes. In most cases, monitoring should focus on actual and correct maintenance and use of facilities and systems, rather than administrative reports on outputs.

S1: Type of sanitation facility used

“What type of sanitation facility is used” is the most fundamental indicator of sanitation, and the most widely used sanitation criterion. For global reporting purposes the JMP has developed an ‘improved/unimproved’ classification system (see Appendix 2.6). For comparison against global datasets, projects and programs are encouraged to use a similar classification. It should be recognized that some sanitation systems classified as ‘improved’ may not wholly isolate feces from the environment, and can lead to degradation of water resources used for e.g. recreation, fishing, or even drinking-water.

S1 “Type of sanitation facility used” can be reported or observed. Most commonly survey respondents are directly asked what type of sanitation facility they use. The JMP core question for use in household surveys reads “What kind of toilet facility do members of your household usually use?” with responses coded according to the technologies in Appendix 2.6. Questions and responses are always adapted to local circumstances, and translated into local languages. Collecting self-reported use of sanitation facilities through community surveillance is inexpensive and efficient, and reasonably valid: comparison with independent observations shows that people generally accurately report the type of facility used, though they may over-report the consistent use of the facility by all family members. Small children, in particular, may not be expected to use the same type of facility as adults, and management of child feces should be measured separately (see S13).

Government agencies often prefer administrative reporting over household surveys: coverage is calculated on the basis of funds invested, or a theoretical number of systems constructed. This kind of ‘output indicator’ is simple as no field work is required. However, political pressures can easily lead to inflation. India’s Total Sanitation Campaign relied on administrative data, but the rapid progress reported was not always borne out by independent household surveys (‘use/outcome indicators’). Figure 5.1.3 shows good correlation between administrative reports and household surveys in one state, and unreliable results in another. While very efficient, administrative data may be invalid, and should only be relied upon when they can be independently confirmed.
Projects often try to encourage target populations to ‘move up the sanitation ladder’ – e.g. first shifting from open defecation to fixed point defecation, even using unhygienic facilities. Later people are proposed to progressively use better quality facilities.

Actual use can be measured through structured observation or through objective sensors (Clasen, Fabini et al. 2012). While sensors may give more accurate measures of use of sanitation facilities, though these are highly expensive and are more likely to be useful in research settings, rather than program monitoring and evaluation.

**S2: “Number of households sharing sanitation facilities”**.

There is currently no empirical evidence that shared latrines are less protective of health than individual ones. This reflects partly a lack of evidence: we are aware of no studies that have compared user density against diarrheal disease outcomes. Montgomery et al. (2010) found no difference in trachoma rates when comparing users of shared versus private latrines.

**BOX 6.1: Shared Sanitation**

*Shared sanitation can be defined as “sanitation facilities of an otherwise acceptable type that are shared between two or more households, including public toilets” (WHO/UNICEF 2012). This reflects the concern that when multiple families share a facility, it is likely to be kept less clean, as well as less accessible, especially at night. However, latrine sharing among a small number of families (often related) is very common in some rural areas, and does not necessarily compromise cleanliness or access. In low-income high-density urban areas, shared sanitation may be the only alternative to open defecation, and well-managed community toilets may be perfectly able to hygienically separate feces from the environment (though accessibility at night may be restricted). If shared sanitation were counted as improved, the world would be ‘On Track’*
Monitoring of facility sharing is a particular challenge in urban settings or institutions, with public facilities. Survey respondents may not know the number of users of community toilets; this information may be collected from toilet managers or through observation.

**S3: “Distance to sanitation facility” and S4 “Round trip travel time to use sanitation facility”**

In household surveys, respondents may not be able to accurately estimate the distance to sanitation facilities, and travel time is considered to be more valid. Travel time should include any queuing. GIS sanitation databases can calculate distance (either linear or along paths) and can be useful for planning purposes, especially in dense urban settings.

**S5: “Accessibility at all times”**

Facilities should be accessible to all, including those with special access needs, such as children, persons with disabilities, elderly persons, pregnant women, parents accompanying children, chronically ill people and those accompanying them. Paths leading to facilities should be safe and convenient for all users. S5 is not routinely collected in household surveys, so it is difficult to judge the validity of indicators. However, it would be easy and inexpensive to add an appropriate question to specialized surveys, and gradually learn more how to effectively measure accessibility.

**S6: Fecal sludge management systems**

While improved sanitation facilities can initially separate feces from the environment, latrines fill up and may become abandoned. Another risk is that unhygienic emptying and disposal of fecal sludge can reintroduce pathogens into the environment. Sludge management is especially important in urban settings, where room for storage is limited and multiple users lead to rapid filling of pits or tanks. Emptying storage units poses both a threat to human health (release of pathogens to the environment) and to sustained use of the facility (users may abandon systems rather than empty them) (Tilley, Lüthi et al. 2008).

Therefore GIZ calls for fecal sludge management (GIZ 2012):

“He or she uses a toilet that is embedded in a functioning sanitation system, whereby the excreta from the toilet is collected, stored (if applicable) as well as transported (if needed), treated and disposed or reused in a manner which minimizes contact between human excreta and humans or animals, is not hazardous to human health and not detrimental to the environment”

Indicators of sludge management are not routinely collected, and their validity and links to health outcomes have not been assessed. Evans et al. suggest a set of potential indicators: survey teams can seek out visual evidence that full latrine pits have been emptied or replaced; that pits could be emptied or that there are plans for treatment/re-use or disposal of fecal matter; or that sludge has previously been safely re-used or disposed (Evans, Colin et al. 2009). These are logical but have not been widely used and validated. Priority should be given to developing valid indicators for sludge management.
Where sanitation interventions directly target fecal sludge management, or where public facilities are managed, indicators may be easier to develop and collect.

**S7: Is the sanitation facility clean?**
S7 is an outcome indicator which can be collected through household surveys. Surveyors may record their observed assessment (“Are feces visible on or around the latrine?”) in which case clear guidelines and trainings are needed to ensure objectiveness and reproducibility. Alternatively, household respondents may give their own assessment (“Do you consider this latrine to be clean?”), which is inherently subjective. A range of responses (e.g. Likert scales) can give more useful information than simple yes/no questions.

**S8: Is the sanitation facility regularly maintained?**
S8 is a process indicator, which can also be collected through household surveys. However, in professionally managed systems (e.g. public facilities in urban areas) household respondents may not have full information. In informal systems, simple questions like (“Who is responsible for cleaning the latrine? How frequently is the latrine cleaned?”) can yield useful information.

**S9: Does the sanitation facility meet minimum technical standards?**
Minimum technical standards will depend on local requirements, but generally require that facilities:

- Are fly proof (preventing flies carrying fecal contamination to the wider environment)
- Separate excreta from human contact
- Eliminate bad smells
- Do not contaminate surface water

**S10: Access to hand-washing facilities**
Presence of a handwashing facility can be easily recorded for community toilets, and should be considered a valid output indicator, but does not necessarily indicate use of the facility. Indicators for actual handwashing practice are considered in section 5.2.3.

**S11: Cost of water and sanitation**
Calculation of expenditure ratios for water and sanitation is not easy. Both the numerator (how much is spent) and the denominator (how much income is available) are ill-defined, hard to collect, and can vary tremendously with time. Expenses may be ‘lumpy’: how should connection fees for water or sanitation networks be accommodated? How should time costs be valued, if at all? Or economic costs such as care for diseases which could be prevented by improved WASH?

Income also can vary from month to month, especially in subsistence agricultural economies. In order to avoid complications in measuring income, some suggest that expenditures on water and sanitation should be considered with reference to easily obtainable figures, such as the national poverty line, or median income among the poorest quintile.

**S12: Privacy**
If cultural requirements are known, information on privacy and cultural acceptability can be collected through surveys, either observed by data collectors (Does the latrine have a door? Are there separate facilities for males and females?) or self-reported.

**S13: Management of child feces**
The QVZ definition of sanitation (GIZ 2012) is made at the individual level. But poor sanitation practices by one person has impacts on other people in the household or community (in economics terms, there are externalities), and it is advisable to consider indicators at larger scale.

At the **household scale**, child feces are often managed separately from adult feces. They may be considered harmless, though in fact child feces can have higher pathogen loads than adult ones. Special attention should therefore be given to management of child feces. Self-reported practice in surveys may not be reliable; more objective measurements can be gained through observation. Structured observation of household behavior (e.g. Huda, Unicomb et al. 2012) is considered highly valid but is expensive. Casual observation by surveyors (e.g. do small children wear diapers) has also been linked with disease outcomes and is significantly less expensive; this could be an effective indicator in certain contexts (Gorter, Sandiford et al. 1998).

**S14: Open Defecation Free status**
At a larger scale, entire communities can be targeted for sanitation improvements, e.g. in the Community Led Total Sanitation (CLTS) approach. Monitoring indicators should also apply at the **community scale** (typically the village targeted). In most CLTS schemes, communities which have achieved improved sanitation by all declare themselves to be “Open Defecation Free (ODF)”. ODF status is then verified by higher authorities, and may be tracked over time. This indicator is quite practicable, but the quality depends highly on the verification process – authorities may have incentives to over-report ODF status (see Figure 5.1.3). Other proposed indicators of community scale sustainable sanitation include government disbursements of awards to villages or administrative units for achieving ODF status (WSP 2012), or the degree to which new members of the community (in-migrants or new adults) construct and use hygienic latrines (Evans, Colin et al. 2009).

### 6.1.4 Summary table: principal indicators for sanitation
The following table lists the most promising sanitation-related indicators. All of these are measures of actual use, which have in at least some studies correlated with health outcomes. Output indicators (e.g. number of latrines built; administrative records) should not be considered sufficient for evaluations.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 Type of sanitation facility used</td>
<td>Should be considered in nearly all evaluations.</td>
</tr>
<tr>
<td></td>
<td>+ Easy to measure in household surveys.</td>
</tr>
<tr>
<td></td>
<td>+ Compatible with global and national datasets</td>
</tr>
<tr>
<td></td>
<td>- Doesn’t include cleanliness.</td>
</tr>
<tr>
<td>S6 Fecal sludge management systems</td>
<td>Should be included in interventions which specifically target</td>
</tr>
<tr>
<td></td>
<td>fecal sludge management.</td>
</tr>
<tr>
<td></td>
<td>+ Conceptually important for isolating pathogens</td>
</tr>
<tr>
<td></td>
<td>+ Fecal sludge management is important for sustainability.</td>
</tr>
<tr>
<td></td>
<td>- Not easy to measure.</td>
</tr>
<tr>
<td>S7 Is the sanitation facility clean?</td>
<td>Should be considered in most evaluations.</td>
</tr>
<tr>
<td></td>
<td>+ Easy to measure in household surveys.</td>
</tr>
<tr>
<td></td>
<td>- Assessments can be subjective.</td>
</tr>
</tbody>
</table>
Management of child feces

Should be included in most evaluations.
+ Conceptually important for isolating pathogens, child feces are often not considered hazardous
- May be subject to courtesy bias

Open Defecation Free status

Should be considered in all evaluations of CLTS interventions.
+ Easy to measure in household surveys.
+ Compatible with global and national datasets
- Political pressure to report ODF status: need for independent and unbiased verification.
- How to consider slight deviations (e.g. improper disposal of child feces)

There is little empirical evidence regarding the optimal frequency of monitoring for these indicators. The focus of evaluations will be on the prevalence of these behaviors, not on their incidence, so cross-sectional studies will be suitable. For most indicators, single measures before and after the intervention will be adequate, provided that the follow-up survey is made in the same season as the baseline.

6.2 Hygiene

6.2.1 Interventions and impacts for hygiene: State of research

Hygiene interventions act as a barrier to pathogen transmission by preventing the transmission from fingers to food, drinking water and health (see pathogen transmission model in chapter 3.1). In addition, hygiene interventions prevent the pathogen transmission from contaminated fields or flies to food. Hygiene interventions require a substantial behavioral change among beneficiaries (Waddington, Snîlstveit et al. 2009). Hygiene interventions that have scientifically tested typically fall into one of the following two categories: general hygiene education and/or promoting hand-washing. Fewer studies have analyzed interventions preventing the pathogen transmission from fingers to drinking water by improved transport and storage containers, and food protection – as a measure preventing the pathogen transmission from fields and flies to food. There is relatively little information about other types of hygiene and their impacts on health.

The effectiveness of hygiene measures as a means of reducing diarrhea as well as dysentery has been confirmed in a number of randomized trials and selected hygiene measures seem to be as effective as hardware WASH interventions (Fewtrell, Prüss-Üstün et al. 2007; Zwane and Kremer 2007). However, it is often difficult to clearly identify the effect of hygiene education, as hygiene education is often undertaken in combination with improved sanitation and water supply (Fewtrell, Prüss-Üstün et al. 2007).

A randomized controlled trial (RCT) undertaken in Pakistan (Luby, Agboatwalla et al. 2005) showed that a hand-washing promotion campaign aiming at mothers showed a reduction of 39 per cent fewer days of diarrhea of infants and malnourished children under age five living in treatment households compared with the control group after one year of intervention. (Curtis and Cairncross 2003) conducted a meta-analysis of the impact of hand-washing with soap on diarrhea morbidity. The results of this meta-analysis suggested that hand-washing with soap can reduce diarrhea morbidity by 47 per cent (see Fewtrell, Prüss-Üstün et al. 2007; Zwane and Kremer 2007). This result has been confirmed by a later meta-analysis of Cairncross et al. (2010). Moreover, (Fewtrell, Prüss-
Üstün et al. 2007; Waddington, Snilstveit et al. 2009) suggest that soap provision is more effective in reducing diarrhea morbidity than education campaigns.

(Günther and Schipper 2012) show that improved water transport and storage containers can lead to a reduction of *E. coli* contamination of drinking water by 70 per cent and to a reduction of diarrhea incidence by 25 per cent among household members aged 5 years and older. The area of food hygiene in developing countries is relatively new, even though for industrialized countries food contamination is recognized to be a significant cause of morbidity. While limited evidence suggests that pathogen levels in foods in developing countries are high (Touré, Coulibaly et al. 2011), interventions are few (Curtis, Schmidt et al. 2011), but might be effective in improving food hygiene and quality (Touré, Coulibaly et al. 2013). In Bangladesh, among various measured hygiene practices the single greatest impact (70% less diarrhea prevalence) was in households where residents were observed to wash hands with soap before food preparation. Even when residents were observed to wash hands with water only, a diarrhea incidence was 33% lower (Luby, Halder et al. 2011).

There is increasing evidence that handwashing practices after contact with fecal matter are considered as a very different behavior than handwashing before contact with food by target populations (Luby 2011a; see also Contzen & Mosler, 2012a). Promotional strategies therefore need to be developed separately for these two sets of handwashing practices.

Table 5.2: Examples of hygiene related impact studies and their measured health effects

<table>
<thead>
<tr>
<th>Reference</th>
<th>Approach/Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Günther and Schipper 2012)</td>
<td>Impact of improved water transport and storage containers on <em>E. coli</em> contamination</td>
<td>Reduction of <em>E. coli</em> contamination of 70 per cent, reduction of diarrhea incidence of 25 per cent</td>
</tr>
<tr>
<td>Cairncross et al. (2010)</td>
<td>Impact of promotion of handwashing with soap on diarrhea</td>
<td>42-48 percent reduction in child diarrhea</td>
</tr>
<tr>
<td>(Waddington, Snilstveit et al. 2009)</td>
<td>Handwashing with soap and hygiene education and their impact on child diarrhea morbidity</td>
<td>31 per cent reduction in child diarrhea morbidity</td>
</tr>
<tr>
<td>(Fewtrell, Prüss-Üstün et al. 2007)</td>
<td>Health and hygiene education, Promotion of handwashing</td>
<td>Reduction of diarrheal illness level through hand-washing: 44 per cent, Reduction of diarrheal illness level through hygiene education 28 per cent</td>
</tr>
<tr>
<td>(Curtis and Cairncross 2003)</td>
<td>Impact of handwashing with soap on diarrhea morbidity</td>
<td>Reduction of diarrhea morbidity by 47 per cent</td>
</tr>
</tbody>
</table>

6.2.2 Target behaviors and behavior change for hygiene

Several hygiene behaviors have to be taken into account: handwashing, food hygiene, body hygiene, and housing hygiene. Excreta management and protection of drinking water can also be considered as hygienic practices, but these are addressed alongside broader considerations for sanitation and water. Hygiene does not need expensive hardware interventions it can be performed when households or settings like schools; day-care centers etc. have water and soap. Nevertheless are
handwashing stations (e.g. tippy-taps) promoted because they make handwashing more convenient. For hygiene behavior the focus lies on software interventions often called hygiene promotion. In this chapter we display the kind of behaviors to be changed, their behavioral determinants, and the literature about behavior change projects in this sector.

The most researched hygiene behavior is handwashing with soap. Handwashing should be performed in many key situations during everyday life which can be divided into situations after contact with feces and situations before handling food (Contzen and Mosler 2012).

- Situations after contact with feces: after defecation, after wiping a child’s bottom, after disposing of feces.
- Situations before handling food: before eating, before preparing food, before feeding a child, before handling drinking water.
- Food hygiene includes hygienic handling and cooking of food; reheating of prepared food; clean cookware as well as safe storage of food so that animals and especially flies don’t have access.
- Body hygiene contains washing the body with water and soap, trimming fingernails, wearing clean clothes and menstrual hygiene.
- Housing hygiene comprises safe storage of cookware, cleanliness of floors and close surroundings of the house.

From all the mentioned hygiene behaviors only the behavior change process of handwashing is well researched. From the many studies which were conducted by Curtis and her colleagues we discuss only the one in which they present a review over eleven countries (Curtis, Danquah et al. 2009). They found that handwashing behavior is motivated by disgust, nurture, comfort and affiliation. Fear of disease was not a motivator for handwashing, except transiently when epidemics occurred. Long term plans about why to perform handwashing were focusing on improving family health and on teaching children good manners. Two studies based on the RANAS model (Mosler 2012) conducted in Haiti (Contzen and Mosler 2012) and in Ethiopia (Contzen and Mosler 2012) revealed more behavioral determinants of handwashing with soap: perceived severity of getting diarrhea, social norms, hindrance, and commitment (Contzen and Mosler 2012) and additionally liking smell of the soap, feeling attractive, and the perceived easiness to perform handwashing (Contzen and Mosler 2012).

In a study in Kenya (WSP 2012a), disgust, nurture, and comfort were identified as main motivators for handwashing among caregivers while justification (the need to wash off germs that cause disease), fun and fitting-in emerged as motivators among school children. The teachers serving as role models and active participants in promotion, and giving verbal reminders of importance of handwashing were facilitators of student handwashing. Barriers in these schools were placement of handwashing facilities (too far from toilet or not on the way to/from the toilet), impractical facilities for children (ex. sink out of reach), overcrowding, lack of water drainage and lack of support from teachers emerged. In this study as well as in one in Vietnam (WSP 2012b)) presence of a convenient handwashing place with soap and water was reported as an important facilitator of behavior and may serve as a physical reminder. In a study in Peru and Senegal (WSP 2012c), beliefs about soap, and access to soap and water were correlated with having soap and water at a designated place. (Biran, Schmidt et al. 2009) investigated a hygiene promotion intervention based on germ awareness finding that observed handwashing did not change 4 weeks after the intervention.
Summing up it became obvious that out of the many hygiene behaviors only the behavioral
determinants of handwashing are well known but the evidence on behavior change strategies is very
low.

6.2.3 Indicators for hygiene
Handwashing with soap and water has been shown to effectively reduce pathogen contamination on
hands. Most hygiene promotion campaigns center on handwashing with soap (HWWS) after
defecation, or after cleaning the feces of a child. Handwashing practice is a personal behavior, so
data collection usually involves household visits. In these visits, information on HWWS can be
collected through self-reports, through proxy measures, or through direct observation. The Water
and Sanitation Program has produced a series of reports which give an excellent overview of the
validity and efficiency of various possible handwashing indicators (Ram 2010; Ram, Luby et al. 2010;
Ram 2013). The most relevant of these are summarized below, and named H1-H7.

H1: Self-reported handwashing after defecation
H1: Self-reported handwashing practice is easy to collect during surveys, but numerous studies have
shown that people significantly over-report handwashing when compared to structured observation.
In Bangladesh, 77% of respondents reported washing hands with soap or ash, but only 32% were
observed to do so (ICDDB 2008). This over-reporting may reflect an awareness of the social
desirability of handwashing, and self-reports may give useful information about knowledge of
handwashing, or prevailing social norms, if not actual practice. Although several studies have found
links between self-reported HWWS and disease outcomes including child mortality (Ram 2013), the
consistent over-reporting in self-reports makes this indicator invalid for most monitoring purposes.

H2: Proxy indicators of handwashing
H2: Given the limitations of self-reporting, and the expense of structured observation, a number of
proxy indicators of handwashing have been proposed. There is particular interest in rapid
observations which could be made by surveyors. Biran (2008) compared 26 proxy indicators against
structured observation in rural India, and found that none matched structured observation well. The
best proxies were ‘observed presence of soap by latrine or in yard’. Another marginally valid
indicator was the use of soap when asked to demonstrate handwashing practices. This same
indicator was found to correlate with a 31% lower prevalence of diarrheal disease in Bangladesh
(Luby, Halder et al. 2011). In both studies soap was used more than twice as frequently in
demonstration than in structured observation. This indicator is valid as a relative, not absolute,
indicator of handwashing practice. Both are inexpensive and easy to collect, so have high efficiency.
Since 2009, the Joint Monitoring Programme has recommended recording, through observation, the
availability of soap and water in the place where household members usually wash their hands.

H3: Direct measures of hand cleanliness
Rather than try to measure handwashing, some have attempted to measure hand cleanliness
directly. Fecal indicator bacteria can be measured on hand samples, but this is time-consuming and
expensive. Furthermore, repeat measures show great variability over time, and poor correlation with
handwashing (Ram, Jahid et al. 2011). However, a much simpler proxy indicator shows validity, as
well as efficiency: visual observation of children’s finger pads. Households in which the surveyor
judged all children’s fingers to be clean were 18% less like to have diarrhea (Luby, Halder et al. 2011).
H4: Observed HWWS after defecation (structured observation)

H4: The commonly accepted ‘gold standard’ for handwashing practice is structured observation. Usually observation lasts at least five hours, during which surveyors observe and recall all defecation events and subsequent handwashing practice. In some cultures defecation is predominantly practiced in the early morning, complicating field data collection. Individual practices are highly variable, so structured observation should be made of large numbers of individuals, implying significant costs (Cousens, Kanki et al. 1996). Social pressures may cause people to wash hands with soap more when they know they are being observed. This ‘reactivity’ was investigated in Bangladesh by comparison of structured observation against handwashing practice as measured by soap bars with embedded motion sensors. On days when observers were present, the sensors recorded about 35% more movements. Reactivity was higher in wealthier households, perhaps reflecting perceptions of socially desirable behaviors (Ram, Halder et al. 2010). Thus the validity of structured observation may be questioned. Large-scale adoption of motion sensors as a reference method is not practical: the equipment is expensive and complicated, and cannot at present be widely utilized for monitoring and evaluation. Households in which structured observation revealed HWWS after defecation experienced significant reductions in diarrheal disease (Luby, Halder et al. 2011) and this indicator should be considered the most valid available indicator of HWWS. It may be possible to modify structured observation to reduce the reactivity, but the high cost of structured observation will limit its application to research activities and evaluation of large programs.

The area of food hygiene in developing countries is relatively new, though in wealthy countries food contamination is recognized to cause significant morbidity. While some studies in low and middle income countries have shown that food can contain high levels of fecal indicator bacteria or pathogens, interventions and associated indicators are few (Curtis, Schmidt et al. 2011). A recent study in Mali showed that weaning foods were highly contaminated, and suggested four possible interventions (Touré, Coulibaly et al. 2011):

- Washing hands with safe running water and soap (including local soap), at the critical moments (before starting meal preparation, feeding children or eating, after cleaning a child’s bottom and after using latrines),
- Washing dishes with safe running water and soap (including local soap), using safe water for the preparation of food as well,
- Cooking and reheating foods until boiling, and
- Covering foods with tight-fitting lids during storage.

In a small-scale trial, these behaviors were promoted and achieved large reductions in food contamination. The practice of reheating food was easily understood and adopted, even though it is not a traditional practice in the local culture (Touré, Coulibaly et al. 2013).

H5: Observed HWWS before food preparation (structured observation)

Handwashing is also frequently promoted around food-related events. HWWS is universally low around food management, but has been shown to be significantly linked with health. While superficially similar, handwashing around food handling is a very different behavior from handwashing after contact with fecal matter, and promotion strategies and materials should be developed separately.
Self-reported handwashing before food preparation was not found to be valid: reported rates were much higher than observed and did not correlate with disease burden (Luby, Halder et al. 2011).

**H6: Self-reported HWWS before feeding a child**

H6: In a related study in Bangladesh, caregivers were asked an open-ended question about when they wash hands with soap. In households where respondents reported usually washing hands before feeding a child, diarrhea risk was reduced by 40% (Luby, Halder et al. 2011).

**H7: Handwashing before eating**

Handwashing before eating is sometimes targeted, but has not been linked with reduced diarrhea. Further evidence is required to support promotion of handwashing before eating.

**Menstrual hygiene management** has gained increasing attention in recent years (WaterAid 2012). Menstruation is in many cultures taboo, and menstruating women and girls are sometimes forced into seclusion and prevented from participating in daily activities. There is strong anecdotal evidence that menstruating girls are less able to attend school. Direct health impacts of poor menstrual hygiene are not well documented, though some reports suggest that impacts can include urinary or reproductive tract infections. Menstrual hygiene interventions normally aim more at improving the psychological wellbeing of women and girls.

**6.2.4 Summary table: indicators for hygiene (handwashing)**

Handwashing is a behavior and all of the principal indicators are Use (or Behavior) indicators. Other aspects of hygiene (e.g. covering of food, menstrual hygiene management) should be considered if those behaviors are targeted by the intervention being monitored.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Self-reported HWWS after defecation</td>
</tr>
<tr>
<td>H2a</td>
<td>Proxy: Observed presence of soap by latrine or in yard</td>
</tr>
<tr>
<td>H2b</td>
<td>Proxy: Spontaneous use of soap when asked to demonstrate handwashing</td>
</tr>
<tr>
<td>H3</td>
<td>Visual observation of children’s finger pads</td>
</tr>
</tbody>
</table>
### 6.3 Drinking water supply and quality

#### 6.3.1 Interventions and impacts for drinking water: State of research

Interventions to improve coverage and safety of drinking-water supply and drinking water quality act as barriers to negative health influences caused e.g. by pathogens, and can be applied at any step from source to point of consumption, including treatment, storage, distribution and collection of water. Furthermore, interventions in sanitation may also influence the safety of drinking water supplies where they can prevent contamination of source waters. Measures in source water protection aim at preventing contamination being introduced to the system in the first place, and treatment steps can reduce or eliminate biological, chemical, physical or radiological hazards in the system. However, even if water is safe when leaving the treatment steps, it may still be re-contaminated during distribution, storage, collection or at the household level. Therefore, the multiple-barrier-principle may increase water safety through measures at several steps within the water supply: while one single barrier may fail, the others may still work properly. For example, point of use (POU) water interventions such as SODIS (solar UV radiation), chlorination, ceramic filtration, biosand filtration, or boiling act as a direct barrier between (contaminated) water and health before consumption.

Various scientific studies examine the impact of both water supply and point of use water interventions on water quality and health. Available studies also compare cost-efficiency of source interventions versus point of use interventions.

Most studies suggest that water quality interventions at point of use are more effective in reducing diarrhea risk than simple water supply interventions, irrespective of the evaluation quality (Waddington, Snilstveit et al. 2009). Randomized trials with large samples only find limited health impacts of improved communal water sources, but larger effects of improved private piped water supply (Wright, Gundry et al. 2004; Zwane and Kremer 2007; Waddington, Snilstveit et al. 2009; Günther and Schipper 2012). In some few cases diarrheal disease actually was found to increase among users of private piped water (Klasen, Lechtenfeld et al. 2012). The key problems seem to be interrupted water provision with low water quality at the tap as well as households starting to
storage water (even with access to private piped water). This study is in line with an intervention in Uzbekistan (Semenza, Roberts et al. 1998), in which diarrheal disease was lower among users of piped water than other sources, but lower still among households practicing household chlorination of non-piped water. These results highlight the importance of a focus not only on ‘improved’ supply technology, but on water quality.

For communal water supply, various studies (e.g. Wright, Gundry et al. 2004; Trevett 2005; Günther and Fink 2013) show that water quality at point of use is often of much lower quality than water quality at the point of water collection, which means that rural households with access to safe water sources might still drink contaminated water at the household level. Due to improper hygiene and recontamination of water from safe sources the provision of microbially safe water at public taps or pumps has, therefore, often limited health effects. The recontamination of water from a safe water source can occur during water collection, transport, unsafe storage and/or handling of water at home. Moreover, (Gross, Günther et al. 2013) have shown that safe water handling (i.e. covered transport and storage) and water treatment might even decrease after installation of modern water infrastructure. However, safe storage and handling of water can minimize recontamination, and can lead to significant improvement of water quality in the household (Günther and Schipper 2012).

Table 7: Examples of improvements in drinking water supply and quality and their measured health effects

<table>
<thead>
<tr>
<th>Reference</th>
<th>Approach/Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Günther and Fink 2013)</td>
<td>Impact of improved (in comparison to unimproved) water supply on diarrhea, stunting, and mortality</td>
<td>Private piped: Diarrhea -9 per cent; Stunting -9 per cent Public improved: Diarrhea -8 per cent; Stunting -3</td>
</tr>
<tr>
<td>(Cairncross, Bartram et al. 2010)</td>
<td>Impact of POU water quality interventions</td>
<td>17 per cent reduction in diarrhea</td>
</tr>
<tr>
<td>(Waddington, Snilstveit et al. 2009)</td>
<td>Impact of water supply interventions on child diarrhea Impact of water quality interventions(^{10}) (source or POU) on diarrhea</td>
<td>No health effects for water supply POU water quality treatments more effective than treatment at water source</td>
</tr>
<tr>
<td>(Arnold and Colford 2007)</td>
<td>Impact of POU chlorination (at household level) on E. coli contamination</td>
<td>Reduction of 80 per cent in E. coli contamination Reduction of 30 per cent in diarrhea</td>
</tr>
<tr>
<td>(Kremer, Leino et al. 2006)</td>
<td>Impact of source water quality improvement through spring protection on child diarrhea and nutrition (randomized evaluation)</td>
<td>Spring protection reduces E. coli contamination by 73 per cent at source, no significant effect on child diarrhea and nutrition</td>
</tr>
</tbody>
</table>

\(^{10}\) Water quality interventions provide the means to protect or treat water for the removal of microbial contaminants and / or save storage (Waddington et al. 2009)
(WHO 2011) provides a risk-based framework for assessing the performance of interventions of water treatment at the household level. This document also stresses the need to establish health-based microbiological performance targets against which the options can be assessed, and gives guidance on how to do so applying the concept of tolerable disease burden. The guiding principles that have been used in the development of these recommendations for microbiological performance targets are as follows:

- Technologies should be as effective as possible against all classes of microbes (bacteria, viruses and protozoa).
- Technologies that are effective against two but not all three classes of pathogens (bacteria, viruses and protozoa) may be recommended for use if supported by epidemiological evidence of positive health impacts.

Consistent and continuous use of household water treatment technologies is required for improvements in health associated with the consumption of drinking-water.

While limited health impacts are found for improved public water supply interventions, water quality interventions at the household level seem to be highly effective in reducing water-related diseases (Kremer, Leino et al. 2006; Waddington, Snilstveit et al. 2009; Günther and Fink 2013). Household water treatment can ensure microbiological safety of water, though treatment must be highly consistent in order to realize health benefits (Brown and Clasen 2012). According to meta-studies (Arnold and Colford 2007) POU chlorine treatment reduces E. coli contamination on average by 80 per cent and reduces diarrhea by 30 per cent. However, despite the high effectiveness and low costs of chlorine treatment the usage rates in the long run are still low because of the bad taste of the water, the behavioral change required, and the high time costs of treating water. Low usage rates were also reported to be a large problem for other water treatment technologies, such as boiling, solar disinfection or water filters requiring fundamental behavioral changes (Gundry, Wright et al. 2004; Sobsey 2008; Waddington and Snilstveit 2009; Günther and Fink 2013). Only a thorough evidence-based behavior change approach guaranties high and continued usages rates of 65% as shown by (Mosler, Kraemer et al. 2013). Moreover (Cairncross, Hunt et al. 2010) and (Brown 2013) have recently questioned the stated high impact of POU water treatment, given that blinded studies do not find any effect of POU water treatment on self-reported diarrhea. They argue that POU water quality interventions do not reduce diarrhea by more than 20 percent.

**6.3.2 Target behaviors and behavior change for drinking water**

Only hardware interventions provisioning people with safe water sources (free from bacteriological and chemical contaminants) will not always improve health. Particularly for supplies which require water collection by users, and / or storage of water at the household level, behaviors may have to be performed by consumers to assure that the water used for drinking and cooking is safe:

- Collecting drinking water exclusively or at least to a high percentage (>80%) from a safe source
- Regular cleaning of transportation containers
- Safe storing of drinking water in-house
- Regular cleaning of the scooping and drinking vessels
- Point-of-use disinfection of drinking water

From all these behaviors mainly the point-of-use disinfection is researched with only few exceptions as a recent review (Parker Fiebelkorn, Person et al. 2012) demonstrates. Point-of-use treatment methods include disinfection with sodium hypochlorite, with flocculent-disinfectant, with chlorine, filtration with e.g. porous carbon block, ceramic or granular media water filters, boiling, and solar or UV light water disinfection (SODIS), or combinations of these methods. WHO and UNICEF developed a toolkit about monitoring and evaluating HWTS (2012) with which they try to address inconsistent and incorrect use of HWTS. They suggest monitoring and evaluation of HWTS to include 1) process monitoring to assess program implementation and 2) quantitative analysis through surveys, direct observation and water quality monitoring. The document provides a set of 20 indicators and a decision-tree to assist in the selection of indicators based on program aims and resources. Quick and collaborators (e.g. Quick, Kimura et al. 2002) have investigated water treatment and safe storage in many countries. Their safe water system has three components 1) disinfection with sodium hypochlorite; 2) plastic storage vessels with a lid and spigot; 3) communication about health risks. They report quite high compliance with about 72-95% measurable chlorine in drinking water (e.g. Quick, Kimura et al. 2002).

With the exception of the work of Mosler and colleagues most of the studies do not report which behavioral factors were targeted to change drinking water behaviors. (Heri and Mosler 2008) and (Moser and Mosler 2008) used the Theory of Diffusion of Innovations (Rogers 2003) to determine behavioral factors for the dissemination of solar water disinfection (SODIS). These authors found that cost saving, taste, daily tasks and habit, threat of diarrhea, availability of plastic bottles, descriptive norm, and number of promotion activities experienced were influencing the consumption of SODIS-treated water. (Moser and Mosler 2008) differentiated between early adopters, adopters in the middle of the diffusion process, and late adopters. The first group was motivated by increased involvement in the topic of drinking water, the second group additionally by opinion leaders, and the third group by recognition of a majority using SODIS. Several studies used the RANAS model (Mosler 2012) or related models to identify behavioral determinants of using SODIS. (Graf, Meierhofer et al. 2008) identified knowledge and social norms as behavioral determinants in Kenya whereas (Kraemer and Mosler 2010) found in Zimbabwe that the uptake of SODIS was influenced by involvement, ability to perform and social influence. Comparing the intention to drink untreated, boiled, or SODIS water Tamas et al. (in press) found that the liking of each water type and social norms were decisive. (Huber, Bhend et al. 2012) explained the use of household filters removing excessive fluoride with factors from the RANAS model and found that perceived taste, perceived costs of filter material, perceived behavior control, perceived habit, and especially to be able to offer guests filtered water were influential in Ethiopia. (Huber and Mosler 2013) analyzed the buying of fluoride free water from a community filter in Ethiopia and revealed that perceived distance, factual knowledge, commitment, and taste strongly influenced participants’ consumption of fluoride free water.

(Mosler, Blöchliger et al. 2010) interviewed 222 households in Bangladesh to work out the factors influencing the use of arsenic-free deep tube wells. Social factors explained greater variance in the consumption of drinking water from deep tubewells than did situational and personal factors but also self-efficacy and the perceived taste of shallow (arsenic containing) tubewell water proved influential. (Inauen, Hossain et al. 2013) analyzed the use of eight arsenic safe water options (piped water supply, deep tubewells, pond sand filters, community arsenic-removal, household arsenic...
removal, dug wells, well-sharing, and rainwater harvesting) and found that non-users (who had the possibility of using arsenic-safe water) were characterized by greater vulnerability, less preference for the taste and temperature of alternative sources, found collecting safe water quite time-consuming; had lower levels of social norms, self-efficacy, and coping planning; and demonstrated lower levels of commitment to collecting safe water.

With regard to behavior change strategies (Kraemer and Mosler 2010) found that high SODIS consumption was achieved when a household-to-household promotion was followed by a memory-aiding technique such as reminders not to forget SODIS or public commitment (stating publicly to perform SODIS). (Mosler, Kraemer et al. 2013) could show that with their evidence-based interventions containing household visits by trained promoters in combination with persuasion and additionally prompts or public commitment usage rates of 65% or more were obtained and sustained more than two years after the initial promotion, and six months after the end of all interventions.

Tamas and Mosler in Bolivia (2011) as well as (Mosler and Kraemer 2012) in Zimbabwe examined the reasons of people stopping to treat their drinking water with SODIS. The conclusion from the Bolivia study was that relapers rated the taste lower, liked to do SODIS to a lesser degree, perceived less social norms, and were not bothered when forgetting to do SODIS. In the Zimbabwe study users which relapsed to irregular users or even to non-users perceived less vulnerability and severity from diarrhea, felt less social pressure to do SODIS and talked less about SODIS.

Summarizing, behavior change strategies on the consumption of safe water should work with promoters who focus on taste of the safe water, emotions (liking), social norms, and forgetting.

All in all we know a lot about effectiveness of point-of-use disinfection but very little about the factors influencing uptake and sustained practice of household water treatment. Behaviors investigated so far are largely restricted to SODIS and not so much about the behavioral determinants of other disinfection methods. Nearly nothing is known about behavioral determinants and effective behavior change techniques with regard to collecting, transport, storage, and drinking (with a clean cup).

6.3.3 Indicators for drinking water

The GIZ definition of access to water includes six criteria, organized into similar categories as the seven criteria for access to sanitation: (GIZ 2012)

“A person is counted as having access to water if he or she has access to a drinking water source that:

- Is a single household connection shared by family members (usually about six persons per household); or is shared by several families (if possible not more than 5 families or up to 30 persons) within or nearby a plot; or is a community standpost/kiosk in low-income areas serving not more than 400 users per tap and is less than 500 meters away from the household and takes less than 30 minutes to use (round trip);
- Continuously offer a minimum of 20 liters of potable water per capita per day on at least six days per week and six hours per day;
- Provides water free from substances hazardous to human health (according to national guidelines);
• Is regulated and monitored in terms of quality, minimum technical standards and tariff;
• Together with the costs for sanitation results is less than 5% of monthly household expenditure;
• Is culturally acceptable.

As for sanitation, some of these criteria impact only indirectly, if at all, on health outcomes. The QVZ criteria match closely the normative criteria described in the human right to water (UNGA 2009; UNGA 2010), see Annex 2.3. These criteria can be expanded into 10 indicators, labeled W1 through W10 and considered below. An eleventh indicator is considered, for household water management.

**W1: Type of drinking water source**

As for sanitation, the primary indicator for water should be the type of facility used by people. People may use water from different sources for different purposes, but the primary concern should be drinking water. Different water sources may be used at different times of the year; this poses a distinct challenge for monitoring.

For global reporting purposes the JMP has developed an ‘improved/unimproved’ classification system.

<table>
<thead>
<tr>
<th>Improved and Unimproved Drinking Water Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Improved</strong></td>
</tr>
<tr>
<td>• Piped water into dwelling, yard or plot</td>
</tr>
<tr>
<td>• Public tap or standpipe</td>
</tr>
<tr>
<td>• Tubewell or borehole</td>
</tr>
<tr>
<td>• Protected dug well</td>
</tr>
<tr>
<td>• Protected spring</td>
</tr>
<tr>
<td>• Rainwater collection</td>
</tr>
</tbody>
</table>

*The JMP considered bottled water to be improved only when the household uses drinking-water from an improved source for cooking and personal hygiene; where this information is not available, bottled water is classified on a case-by-case basis.

‘Improved’ drinking-water sources are, due to the nature of their construction, more likely to provide safe drinking-water than sources characterized as ‘unimproved’. The JMP core question for use in household surveys reads “What is the main source of drinking water for members of your household?”. This information is easily collected, and projects and programs are encouraged to use a similar classification to allow comparison against global datasets. There is anecdotal evidence that self-reports of water sources match well with surveyor observations, this not been rigorously assessed.

Importantly, however, it should also be considered that whereas ‘improved’ sources of drinking-water are generally more likely to provide safe drinking-water, this does not mean that they automatically do so. Therefore, in assessments, it is also helpful to take into consideration the
condition and management of the systems (see W8), as well as data on drinking-water quality (see W7).

The QVZ wording implies that only household connections (individual or shared) or kiosks/standposts should be considered satisfactory, which is not in agreement with the JMP classification scheme (i.e. JMP accepts boreholes, protected wells, protected springs, and rainwater harvesting which are not included by QVZ). To date, the JMP has used a single classification scheme for both rural and urban areas. However, there is concern that some technologies that could provide good water in rural areas might not be able to do the same in urban areas, due to high population density. The JMP Water Working Group has recommended that in urban areas, only piped water (into the dwelling, yard or plot), standpipes/public taps, and (deep) tubewells/boreholes should be considered as ‘Improved’ (WHO/UNICEF 2012). However, this presumption has not been supported empirically.

W2 Number of households/users sharing the water source
A water source which is used by a large number of people may be physically unable to provide a sufficient quantity of water, or might entail long waiting times for users. However, given that separate indicators are proposed for collection time (W4) and quantity (W5), it is not clear that an additional indicator for the number of users adds value.

W3/W4: Time and distance required to collect drinking water
The QVZ proposal (less than 500 meters away from the household; less than 30 minutes to use) is in line with standard recommendations. The JMP Water Working Group chose to focus only on round trip collection time, and also recommended 30 minutes as an acceptable benchmark, considering that survey respondents would be unable to give accurate responses regarding distance, and also that linear distance may not reflect the actual difficulty of accessing a source (WHO/UNICEF 2012). The collection time indicator can be easily and efficiently collected from household surveys.

W5 Quantity of water available
According to the WHO, ‘Basic access’ is considered as at least 20 liters per capita per day, in line with the QVZ recommendation (see also Section 2). In practice, it is difficult to measure the quantity of water available to or collected by households. Survey respondents are unlikely to be able to give valid responses. In the case of public supplies which are metered, quantitative information may be available but the number of people consuming the delivered water is unknown. This JMP Working Group considered that when improved sources are used (W1) and water is continuously available (W6) without long queuing times (W4), it can be assumed that the volume of water available is at least 20 liters per capita.

When water must be collected from outside the home, even if the source theoretically can supply 20 liters per capita those responsible for water collection (typically women and girls) may actually collect far less.

W6 Continuity of service
The QVZ language is ambiguous regarding continuity: a supply delivering water for only 6 hours per day cannot be considered continuous, though it could be reliable. Intermittent supply most likely requires water storage at the household level, which bears the potential of re-contamination due to unsafe storage and / or handling. Continuity of service is particularly important in piped water systems, since intermittent service leads to periods of low or negative pressure within the pipes,
which in turn easily leads to ingress of contaminated water. In theory, piped water systems should aim for continuous pressure in pipes; in reality this is not the case in many developing countries and while continuity of service should remain a long-term goal, delivery for at least 6 hours in a day can be taken as an interim target for shorter-term improvement. The risk of cross-contamination in intermittent piped systems can be reduced by ensuring residual chlorine throughout the network and minimizing opportunities for cross-contamination (e.g. taking care not to pass supply pipes through drains or stagnant water zones) (WHO 2004).

For point sources, which dominate in rural settings, continuity is normally taken to reflect reliability (i.e. timings of access to water are regular) rather than 24-7 access. The QVZ recommendation of at least 6 days per week is similar to the ‘intermediate service level’ of the JMP Working Group, which calls for <2 days of disruption of service in the preceding two weeks.

**W7: Water quality**

Monitoring water quality poses multiple challenges. To begin with, there are multiple parameters which could define water quality. The WHO has set health-based guideline values for 90 different chemicals, as well as for numerous radioactive substances (WHO 2011). It is neither feasible nor desirable to monitor all of these. By far the greatest threat to public health comes from microbial contamination, and water quality monitoring should focus first on microbial safety. Direct measures of water quality are most powerful when combined with measures of management (see indicator W8).

Monitoring of microbial quality is not simple. It is inefficient to directly measure pathogens; instead, fecal indicator bacteria are measured (see side box), as well as other parameters indicating an increased risk or microbial contamination.

**SIDE BOX: Fecal Indicator Bacteria**

There are hundreds or thousands of fecal microbes which can cause disease in humans, some of which require only a few cells to cause infection. Rather than attempting to directly measure pathogens to determine the microbial quality of water, fecal indicators are used to distinguish waters impacted by fecal contamination. An ideal fecal indicator should (WHO 2011):

- be universally present in feces of humans and animals in large numbers;
- not multiply in natural waters;
- persist in water in a similar manner to fecal pathogens;
- be present in higher numbers than fecal pathogens;
- respond to treatment processes in a similar fashion to fecal pathogens;
- be readily detected by simple, inexpensive culture methods.

No single fecal indicator fully meets all of these criteria. The general consensus is that the most suitable fecal indicator bacteria is *Escherichia coli* (*E. coli*), though thermotolerant coliforms (formerly called fecal coliforms) are an acceptable alternative (WHO 2011) (Edberg, LeClerc et al. 1997). Total coliforms are not suitable indicators, since this group includes many non-fecal bacteria. However, total coliforms can be valid indicators of the general cleanliness of a water system and the integrity of piped networks.

While using *E. coli* as a fecal indicator has historically proven highly successful for reducing waterborne disease, it is now well recognized that a number of viral and parasite pathogens are far
more resistant to environmental conditions outside the human body, and to disinfection. Additionally, some of these pathogens are highly infectious – i.e. ingestion of only a few of these organisms implies a high likelihood of illness. It is important to understand that water in which no *E. coli* are detected is likely to be safe from bacterial pathogens such as *Vibrio cholera* or *Salmonella typhi*, and this is likely to cause a substantial health benefit. Nonetheless, such water may yet contain viral and parasite pathogens. The WHO GDWQ therefore suggest using a viral and a parasite indicator as well – not for routine monitoring, but for validating the performance of barriers against pathogen contamination, e.g. in the context of developing a Water Safety Plan.

Intestinal enterococci are also used as fecal indicator bacteria. Although they are less prevalent in feces than *E. coli* (WHO 2011), they can persist longer in the environment. Their use as an indicator has historically been limited by complex and time-consuming culturing methods; newer enzyme-based methods largely eliminate this constraint. (Risebro, Breton et al. 2012) found that among UK children drinking water from untreated rural supplies (i.e. boreholes), diarrheal disease correlated more strongly with drinking water Enterococci than *E. coli*. However, (Levy, Nelson et al. 2012) found that diarrheal disease in Ecuador did not correlate with Enterococci.

*Bacteroides* spp. have also been suggested as indicators of fecal contamination. These bacteria are much more prevalent in feces than *E. coli* or Enterococci, but may also be of environmental origin (van der Wielen and Medema 2010). Culturing of *Bacteroides* has also been relatively complex, though the use of real-time PCR methods e.g. for monitoring quality of recreational waters is growing in popularity. As *Bacteroides* are strict anaerobes, they may decay more rapidly in the environment than other fecal indicators (Saunders, Kristiansen et al. 2009). At present, monitoring of *Bacteroides* is more useful for tracking the source of fecal material (e.g. Jenkins, Tiwari et al. 2009; Casanovas-Massana and Blanch 2013) than as a proxy for fecal contamination.

*Clostridium perfringens* is a species of fecal bacteria which produces spores which are highly resistant to disinfection e.g. through ultraviolet radiation, chlorine, or heat. As such, *C. perfringens* spores can be used as an indicator of previous contamination (e.g. from intermittent problems in piped networks) even when *E. coli* and Enterococci are absent. The spores can also be used as an indicator of the effectiveness of filtration processes in removing protozoa, which are larger.

A low-cost alternative to specific indicator species is the broad class of sulfate-reducing bacteria, which are easily detected with the hydrogen sulfide (H$_2$S) assay (Sobsey and Pfaender 2002). Sulfate-reducers are primarily found in the enteric tracts of humans and animals, though some environmental species exist in the absence of feces. Increasing evidence shows that the H$_2$S test has good specificity and sensitivity to fecal contamination (e.g. McMahan, Grunden et al. 2012; Khush, Arnold et al. 2013), and its ease of use and low cost give it significant advantages over more specific indicators. This test is not considered a substitute for *E. coli* measurement, but could be very useful for at least qualitative evaluation of large numbers of samples in an evaluation. Most commonly the H$_2$S test is applied in a presence/absence format, but the technique could be adapted to a Most Probable Number (MPN) methodology. H$_2$S tests could also be effective as a behavior change technique, since the black color and strong offensive odor of a positive test result could generate strong responses from household members.

Drinking water quality measures of fecal indicator bacteria are all based on culture methods. Samples must be either analyzed in the field (requiring trained personnel and expensive specialized equipment) or transported on ice to a laboratory and analyzed within a few hours of collection. The emergence of cheaper new tests for *E. coli* based on specific enzymes and chromogenic or
fluorogenic media (Bain, Bartram et al. 2012) may simplify monitoring in the future, and reduced time requirements from several days to 18-24 hours. However, even these so-called ‘rapid tests’ mean that information on drinking water quality is not available until water has already distributed and most likely consumed. Non-culture based methods such as quantitative PCR (polymerase chain reaction) hold the promise of yielding results within a few hours (Rogers, Donnelly et al. 2011; Colford, Schiff et al. 2012), and they are valuable for non-culturable pathogens (such as many viruses) but at present such methods are limited by high detection limits (e.g. 50 cells/100 mL for *Bacteroides*, (van der Wielen and Medema 2010)) and high costs. Furthermore, qPCR methods do not distinguish between live and dead pathogens.

In systems with relatively good water quality, where most water quality measurements are negative, it can be more cost-effective to conduct presence/absence tests rather than quantitative measures (WHO 2011). Presence-absence tests require less sample processing and can be cheaper both in terms of consumables and technician time requirements.

Even if microbial monitoring becomes simpler and cheaper, microbial contamination is highly variable in time and space, so single measurements of a source will not give a robust indication of its overall safety. In other words, microbial testing is becoming more **efficient**, but still has limitations regarding **validity**. This is why it is of crucial importance to assess whether water quality management systems (WQM) are in place and how likely a supply is to continuously provide safe drinking water. Complementary to this, the benefits of water quality testing are particularly in confirming this with an independent approach.

Numerous studies have failed to find a correlation between fecal indicator bacteria in drinking water and diarrheal disease (e.g. Levy, 2012). Several explanations can be proposed. First, drinking water is only one among many pathogen exposure pathways, and may not be the dominant pathway. Second, fecal indicator bacteria may not serve as an accurate proxy for the presence of pathogens (see box above). Wu et al. reviewed forty years of studies and found indicators correlated with directly measured pathogens in only 41% of datasets (Wu, Long et al. 2011). False negatives occur when indicator bacteria are absent but pathogens are present: this can occur when indicator bacteria are either absent from human feces (Levy found that fecal samples from one human subject were consistently negative for Enterococci (Levy, Nelson et al. 2012)) or are attenuated or killed more rapidly than pathogens in the environment (Noble, Lee et al. 2004). In contrast, false positives occur when indicator bacteria are derived from the environment rather than from feces: this has been shown to occur for both *E. coli* (Solo-Gabriele, Wolfert et al. 2000) and Enterococci (Byappanahalli, Nevers et al. 2012). Interpretation of indicator bacteria counts is complex: no direct correlation with pathogens should be expected, though the consistent absence of fecal indicators does indicate a low probability of bacterial pathogen presence (Payment and Locas 2011).

For supplies where chlorination is applied to treat possible microbial contamination (e.g. chlorine-based HWTS interventions), measurement of residual chlorine is an objective, valid, and effective indicator of practice (e.g. Harshfield, Lantagne et al. 2012), which is much simpler and rapid than microbial parameters. Where residual chlorine is measured, turbidity should also be measured, since particles can shield pathogens and reduce disinfection efficiency (LeChevallier, Evans et al. 1981). It is further useful to also measure pH, since chlorine is much less effective above pH 7.5. Simple pH strips may be adequate for this purpose, rather than more elaborate electrodes.
While microbial contamination is the greatest concern, some naturally occurring substances may be relevant in some settings. Among the minerals, the toxicity of arsenic and fluoride is the most well-known example, but evidence is increasingly emerging that uranium and chrome (VI) can likewise be relevant (the former not due to its radiotoxicity, but due to kidney damage at concentrations much lower than those relevant in terms of radiological toxicity, while Cr(VI) is being recognized as a naturally occurring carcinogen). Where interventions install groundwater wells, geochemical screening programs prior to well installation are therefore highly relevant. Given the high spatial variability – including small-scale variability – of these minerals, they should be routinely tested once in all new water supplies (and again if there is evidence of changes in groundwater flow) unless there is compelling evidence that occurrence in the program area is negligible. Where highly eutrophic surface water with ‘algal blooms’ is used as drinking-water source, microscopy is useful to check if the green cells are cyanobacteria, as these may be toxic, and filtration to remove the cells will remove a large fraction of the toxins.

Interestingly, where substances are of health concern in drinking-water, they tend to be naturally occurring ones (although toxic cyanobacteria naturally rarely occur in densities high enough to cause health-relevant toxicity; their proliferation is usually due to anthropogenic eutrophication). Anthropogenic chemicals, in contrast, may be of local relevance, often as “hot spots” caused by specific production processes or waste dumps, whereas health-relevant concentrations are rarely a widespread problem. Catchment inspections assessing possibly polluting activities and potential pathways for pollutants to the drinking-water source provide a good indication of whether or not such chemicals are likely to constitute a health hazard (see Schmoll et al. 2006: Protecting groundwater for health: Managing the quality of drinking-water sources; http://www.who.int/water_sanitation_health/publications/protecting_groundwater/en/index.html; and WHO 2007: Chemical safety of drinking-water: Assessing priorities for risk management; http://www.who.int/water_sanitation_health/dwg/dwchem_safety/en/index.html). Sometimes public perception of hazards in drinking-water is inverse to the actual risk, i.e. focusing on chemicals and neglecting pathogens. This perception tends to be reinforced by regulations including standards for a large number of chemicals (in contrast to the typically small number of microbiological indicators), and it may require risk communication rather than a shift in the focus of indicators monitored.

Where POU treatment has been promoted or is widespread, indicators should focus on measuring how consistently household members apply the treatment. It is more difficult to accurately measure use of other HWTS technologies, such as boiling, filters and solar disinfection (SODIS). Self-reports are prone to inflation. Depending on the technology, specific proxy indicators (presence of SODIS bottles on roof; availability of filtered water) may be developed. However, non-chlorine based methods are highly vulnerable to recontamination (e.g. Psutka, Peletz et al. 2011), so direct measures of water quality such as E. coli should be considered along with measures of use. See also the WHO Network on Household Water Treatment and Storage (http://www.who.int/household_water/en/), including the information material provided there.

W8: Design and management of water supply systems

Contamination can occur at many different stages between the water resource and the point of
consumption, and it can be intermittent, thus not necessarily showing up in single samples. A systematic management approach from catchment to consumer is widely recognized as basis for ensuring drinking-water safety, and this has been introduced by the WHO GDWQ in 2004 as Water Safety Framework, including the concept of Water Safety Plan development (see box ...). While this clearly applies to planning, design, maintenance and operation of systems, it is also the most effective approach to assessing their safety: occasional or even regular monitoring of selected parameters as discussed above will provide highly valuable indication of drinking-water safety, but a more comprehensive understanding can be obtained from assessments of the supply system by analyzing the hazards, assessing the health risks they pose and evaluating the likely efficacy of the barriers in place that should prevent microbial, chemical or radiological hazards from reaching consumers.

Where Water Safety Plans are developed or in place, they provide an excellent basis for assessing whether the design and operation of the supply system is likely to be adequate for providing safe water. If the results of operational monitoring as described in the side box demonstrate the control measures to be reliably functioning, this is an excellent indicator of safety, provided the right control measures have been chosen and implemented. The validity of their choice can be assessed on the basis of the documentation of the rationale and consideration behind the choice of the control measures implemented. Where documentation is lacking (often a problem, particularly in small community settings) it may be possible to elucidate this in discussions with those responsible for the system.

A drinking water supply having a validated and active Water Safety Plan would meet the QVZ requirement for regulation and monitoring of quality and technical standards, if not tariff. Technical standards should also take into consideration the accessibility for people with disabilities and of different age groups.

Small community systems, especially point sources like boreholes, dug wells, and springs, are only rarely covered by Water Safety Plans at present. A simple tool for assessing risks at such point sources is a Sanitary Inspection which can be applied by those involved in the operation of the water supply system, as well as those conducting independent surveillance. Sanitary Inspections are simple checklists which can be evaluated quickly and at low cost by sanitarians with a basic technical training, usually resulting in a risk score ranging from 0-10. Template forms are available in WHO publications (WHO 1993), and can be combined with E. coli test results to make a risk matrix (WHO 2011). In some cases Sanitary Inspection scores have correlated with water quality (Mushi, Byamukama et al. 2012), while in others there is little or no correlation (Luby, Islam et al. 2006; Cronin, Breslin et al. 2008).

W9 Affordability (cross-cutting along with Sanitation)
The human right to water doesn’t mean that water services must be free, and a price for water may be an incentive for quality. Many examples show that where the provision of safe water is lacking, particularly the poor pay excessively high shares of their low income to buy water from vendors, and when safe piped water is provided, this often proves cheaper by orders of magnitude, thus relieving the poor households of a major cost. Nonetheless, people may prove unable to pay, and in such situations subsidies for access to safe water to meet basic personal and domestic needs may be a solution. In contrast, disconnecting users from networked supplies in the case of non-payment of bills is likely to cause major public health risks, as infectious disease that these users then contract
from unsafe water will also be spread through other pathways. Note that affordability of water and sanitation services should be considered together, and this indicator is identical with S11. See Section 5.1.3 for a general discussion of indicators of affordability.

W10 Cultural acceptability
It is difficult to compose indicators to measure ‘cultural acceptability’, which are highly context-dependent. In general, participatory planning processes should minimize the risk of water interventions being culturally unacceptable. The development of a Water Safety Plan as outlined in box ... provides an opportunity for participation in the WSP team, particularly for small, community-operated supplies. Indicators of acceptability could include the extent of consultation with end-users during the planning process, and their contribution and participation during subsequent installation, operation and management.

W11 Household water management
The QVZ indicators focus exclusively on water sources. However, drinking water is often contaminated during collection, transport, and storage (Trevett 2005; WHO 2012). There is little experience with indicators of household water management (although the WHO Network for household water treatment and safe storage is promoting “independent research to evaluate interventions by collecting, analyzing and disseminating data on efficacy, cost-effectiveness, health impact, acceptability, affordability, scalability and sustainability”; see http://www.who.int/household_water/research/en/). Perhaps the most common is a survey question about household water treatment, such as the JMP’s standard question “Do you treat your water in any way to make it safer to drink?” which, in case of affirmative reply, is followed by “What do you usually do to the water to make it safer to drink?”. The JMP then classifies water treatment practices, in a fashion similar to the classification of water and sanitation infrastructure.

<table>
<thead>
<tr>
<th>Adequate Methods</th>
<th>Inadequate methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling</td>
<td>Straining water through a cloth</td>
</tr>
<tr>
<td>Adding bleach/chlorine</td>
<td>Let it stand and settle</td>
</tr>
<tr>
<td>Use of a water filter (ceramic, sand, composite)</td>
<td></td>
</tr>
<tr>
<td>Solar disinfection</td>
<td></td>
</tr>
</tbody>
</table>

This indicator should be considered under development: water is not necessarily of better quality in households which report treating water (e.g. Psutka, Peletz et al. 2011), and we know of no observational studies finding lower diarrheal disease in households reporting treatment of water. Such results are regularly found in experimental studies (e.g. Boisson, Schmidt et al. 2009), but these are much more subject to respondent bias.

Sanitary inspections of conditions of storage and handling of the drinking-water at the household level can give an indication of risks to re-contamination. Survey teams can fairly easily record whether household water is stored in closed containers, and limited evidence suggests that provision of improved storage containers alone can improve household drinking water quality (Gunther and Schipper 2012). Where interventions promote improved household water management, ‘storage in closed containers’ may be a promising indicator for development. Since this information is very simple to collect it could easily be added to household survey modules.
6.3.4 Summary table: indicators for drinking water

Drinking water supply and quality is impacted by many factors, both within the household and at larger scale. No single indicator can capture ‘water safety’, it is rather important to select a set of indicators and make a multidimensional analysis. A good example is the combination of direct water quality measurements (W7) with water management indicators (W8) such as Sanitary Inspection; see Table 6.3.4.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>Type of drinking water source</td>
</tr>
<tr>
<td>W7a</td>
<td>Water quality: fecal indicator bacteria</td>
</tr>
<tr>
<td>W7b</td>
<td>Water quality: residual chlorine, turbidity, pH</td>
</tr>
<tr>
<td>W7c</td>
<td>Water quality: geogenic and naturally occurring chemicals versus chemicals from human activity</td>
</tr>
<tr>
<td>W8a</td>
<td>Water management: presence of Water Safety Plan</td>
</tr>
</tbody>
</table>
6.4 Combined exposure pathways

Combined interventions aim to act as a barrier to pathogen transmission at several points by combining different barriers related to water, sanitation and health interventions (see pathogen transmission model in chapter 3.1). The existing scientific studies assess in randomized trials and observational studies combinations of various possible pathogen transmission barriers. However, and somewhat surprisingly, meta-reviews have not found evidence of a higher impact of multiple interventions compared to isolated interventions of water, sanitation or hygiene provision (Esrey, Potash et al. 1991; Fewtrell, Prüss-Üstün et al. 2007; Waddington, Snilstveit et al. 2009). (Fewtrell, Prüss-Üstün et al. 2007) assess nine interventions which combine the introduction of water, sanitation, and hygiene education measures. Surprisingly, multiple interventions did not seem to be multiplicative, or even additive, or complementary. (Waddington, Snilstveit et al. 2009) reviewed the evidence of combined interventions of three rigorous impact evaluations. In line with the results of the meta-study of (Fewtrell, Prüss-Üstün et al. 2007) they found no clear evidence of a higher impact of multiple interventions. Moreover, in a randomized trial in Pakistan, (Luby, Agboatwalla et al. 2006) could not find any benefit by combining hand washing promotion with water treatment.

Reasons for this result could be the fact that multiple interventions are very ambitious and may result in an overall lack of focus or lack of sufficient attention paid to the single components. For example Greene et al. (2012) have shown that a combined intervention of sanitation construction and hygiene promotion did not lead to the expected results given that latrine construction was not followed by sufficient change in hygiene behavior.

Table 8: Examples of multiple interventions and their measured health effects

<table>
<thead>
<tr>
<th>Reference</th>
<th>Approach/Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Waddington, Snilstveit et al. 2009)</td>
<td>Meta-study of impact evaluations examining multiple interventions (water and sanitation and/or hygiene)</td>
<td>No additional impact of combined interventions</td>
</tr>
<tr>
<td>(Fewtrell, Prüss-Üstün et al. 2007)</td>
<td>Assessment of multiple interventions combining the introduction of water, sanitation and hygiene education measures</td>
<td>Multiple interventions were not additive</td>
</tr>
</tbody>
</table>
In contrast, and in work done after the meta-analyses cited above, in Afghanistan (Opryszko, Majeed et al. 2010) found that the combination of water supply, POU water quality, and hygiene promotion, to be the only intervention which significantly reduced diarrheal disease. Also (Gundry, Wright et al. 2004) have found that the efficacy of water supply and quality interventions depends on the level of sanitation within the targeted community. Similarly, (Eisenberg, Scott et al. 2007) argue that “when community sanitation is poor, water quality improvements may have minimal impact, regardless of the amount of water contamination. Under these conditions of high community transmission, community-level sanitation must be considered a necessary intervention and possibly a sufficient one depending on the level of water contamination.” In any case, (Waddington, Snistveit et al. 2009) argue that whereas complementary interventions might not have an additional positive impact, they may be necessary for the sustainability of the impacts. This also supports the concept of multiple-barrier-approaches.

This suggests that multiple interventions are not necessarily more effective but may be more effective where multiple transmission pathways are responsible for pathogen intake (Eisenberg, Trostle et al. 2012). An analysis of existing transmission pathways and their importance could form the basis of program interventions.

### 6.5 Evidence on specific user groups or locations and cost-effectiveness

Studies providing rigorous evidence supporting decision making on which WASH measures to select for specific user groups or locations are lacking (see also DFID 2012). It remains a task for the future to assess whether a concentration on specific locations or groups as for example schools, toddlers, health centers, slums, markets etc. is more effective. Furthermore, because of the great variation in the way in which specific approaches or technologies are implemented, comparisons are difficult (ibid.). The only context specific studies that are available compare (a) urban to rural areas and (b) analyze schooling environment in particular (with no comparison to general interventions). Diarrhea incidence seems to be highest among (town) slum dwellers and about equal between urban and rural areas (Fink, Günther et al. 2013) and there seems to be an emerging consensus that sanitation infrastructure interventions are more effective (and also in higher demand) in urban (densely populated) areas than in rural areas (Günther and Fink 2011; (Cairncross and Valdmanis 2006; Opryszko, Majeed et al. 2010). See also Section 6.1.

The evidence for schools is mixed. First results of a recently launched program on combined daily supervised hand-washing with soap and biannual deworming lead to a significant decrease in soil transmitted helminthes (STH) infections (of about 50%) and a slight increase in the mean BMI (Monse, Benzian et al. 2013). Reducing STH through deworming in schools has in the last years been hyped as one of the most cost-effective health interventions (Miguel and Kremer 2004). However, a recent meta-study questions the effectiveness of these programs, given that studied interventions were often undertaken in high (non-typical) prevalence areas (Taylor-Robinson, Maayan et al. 2012).
On the other hand, a recent study by (Greene, Greeman et al. 2012) analyzing hygiene promotion in schools did not find an impact on *E. coli* contamination on pupils’ hand and in combination with latrine construction even led to an increase in *E. coli* contamination. The authors hypothesize that this was due to insufficient change in hygiene behavior and absence of toilet paper. The local context may be critical: a randomized control trial in India found that a WASH intervention had no impact on pupil diarrhea in schools where water was available before the intervention, but substantially reduced diarrhea prevalence in schools which initially lacked water sources (Freeman, Clasen et al. 2013). Within a systematic review of the impact of water and sanitation interventions in schools (Jasper, Le et al. 2012), 41 articles were found of which only 10 were conducted in developing countries. Results seem to be positive for schools, but mixed with regard to whether interventions in school can change hygiene behavior at home.

Available cost-effectiveness studies do not differentiate between different settings, and not between different implementation strategies, but between different technologies. (Günther and Fink 2013) estimate that saving a life year with improved water and sanitation infrastructure costs between 30 per cent (for private household water and sanitation connections) and 80 per cent (for basic on-site sanitation and public water infrastructure) of GDP.\(^{11}\) This makes water and sanitation infrastructure an expensive health intervention in comparison to for example immunization or micronutrient interventions, but still a highly cost-effective strategy according to WHO guidelines. WHO considers a cost-effectiveness ratio of less than three times the national GDP per life year saved as cost-effective and an intervention with a ratio equal or less than GDP per life year saves as highly cost-effective. (Günther and Fink 2013) also emphasize that in terms of number of child deaths prevented, water and sanitation infrastructure is unlikely to be matched by any other health intervention. Cost-effectiveness of water and sanitation infrastructure is highest in least developed countries, where current access rates are low and child mortality rates are high. (Laxminarayan, Mills et al. 2006) estimate that hygiene promotion comes at a cost of US$3 per DALY averted, sanitation construction at US$270 per DALY averted, and construction of pumps or public standpipes at US$94 per DALY averted. (Clasen, Cairncross et al. 2007) estimate that the cost per DALY averted is US$123 for pumps or public standpipes, US$55 for household chlorine treatment, US$142 for household filtration and US$61 for household solar disinfection.

Moreover, two important cost-benefit analyses have been conducted. The most cited study (Hutton and Haller 2004) estimates that 1$ invested in water and sanitation infrastructure leads to a return of 5$. However, this result is mainly driven by time savings (which are based on assumptions). (Whittington, Hanemann et al. 2008) argue that the (economic) benefits of centralized (urban) water and sanitation infrastructure are often lower than its costs. For rural boreholes or public standpipes they calculate a benefit-cost ratio of 3.2 (again mainly dependent on time savings) and for household water filters a benefit-cost ratio of 2.7.

Interestingly information on costs of water and sanitation infrastructure (and hygiene promotion) for various settings is scarce and almost all cost-effectiveness studies rely on cost information from 2000 (WHO / UNICEF 2009). Moreover, all cost-effectiveness studies (except Günther and Fink, 2013) focus on diarrhea disease as the analyzed health outcome; even though WASH has additional (important)

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\(^{11}\) For example, for Rwanda the estimated costs per life year saved is US332 for private infrastructure and US577 for basic infrastructure.
health effects on other diseases (see Table 2.2), and there are numerous other indicators which may be applied in order to assess effectiveness of measures (see chapters 6.1-6.4).

7 Analysis of exemplary projects

In this chapter we conduct a critical examination of several projects. We do this by first describing the projects, then discussing some topics important to all projects, and last we evaluate the projects on the background of the conceptual models displayed in chapter 3.

7.1 Short description of the evaluated projects

Benin: Impact evaluation of drinking water supply and sanitation programs in rural Benin. The risk of vanishing effects (Günther and Schipper 2011)

The Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs and the Evaluation Department of the German Federal Ministry for Economic Cooperation and Development (BMZ), conducted a rigorous impact evaluation of rural water supply and sanitation programs in Benin in the period 2008–2010. German development cooperation has been active in the Beninese WSS sector since the late 1960s. The focus of the programs in the rural sector has been on the expansion of water supply infrastructure, mostly hand pumps or foot pumps and small piped systems. German support for investments in water and sanitation programs in Benin is EUR 10.5 million annually on average. In this project neither the deployment of community health workers nor a specific intervention on hygiene and/or sanitation promotion increased toilet use; only the construction of a public latrine increased toilet use in the short term. In 2010, 12% of localities reported a public latrine accessible for the population, only 2% of households actually used a public latrine. Private toilet use was slightly higher, at around 8% of households.


German DC has supported the improvement of drinking water supply there, mainly in urban settings, since the 1960s. This report presents the findings of an impact evaluation of investments to improve water supply and sanitation for urban households in the provincial towns of Amran and Zabid in Yemen. These infrastructure investments, supported by German bilateral DC, took place between 1990 and 2004. This evaluation and sampling design were not intended to study the impact and effectiveness of hygiene training supported by the German technical cooperation (TC). Sanitation seems to be limited to the rehabilitation of the connection of households to piped sewerage systems. Owners of flush toilets are mentioned but not as having gained access to toilet facilities during the project implementation.


In 2007, the Policy and Operations Evaluation Department of the Netherlands Ministry of Foreign Affairs (Dutch acronym: IOB) initiated an impact evaluation of the Netherlands support to rural water supply and sanitation programs in Yemen, covering the period since 1990. From 1983 and 1991, support typically consisted of supply and installation of a water pump, engine, pipes, fittings, a tank or reservoir and metered yard connections; benefiting approximately 70,000 people. The following phases put increasing emphasis on the roles and responsibilities of user institutions at community level with regard to the construction and operation of water supply institutions and a component to strengthen the planning and management capabilities of the General Authority for Rural Electrification and Water Supply. Sanitation and hygiene awareness and measures were also more thoroughly built into each community water scheme, as well as measures to strengthen the role of
women. IOB opted to focus its evaluation study on the longer-term impact up to 2008 of the two later phases implemented between 1991 and 2001. The approach included sanitation and hygiene education campaigns. If scheme households were significantly more likely to have a toilet, differences between project schemes and other water scheme areas are insignificant. In the case of Dhamar scheme there are no significant differences in toilet prevalence between villages with project schemes, other schemes, or no schemes.


From 1971 to the end of 2006 the Netherlands has provided support to rural water supply and sanitation development in Tanzania, Shenyang Region. Over the years, these programs made the transition from construction and rehabilitation of improved water sources (mostly shallow wells) to support to water user communities to establish Water User Groups or Associations and manage their water and sanitation facilities for a long period of time. In addition, the programs increasingly focused on capacity building of stakeholders in the public and private sector to support communities to achieve this objective. The Policy and Operations Evaluation Department (Dutch abbreviation: IOB) initiated an impact evaluation covering the period from 1990 to 2006. The project adopted a demonstration strategy with regard to sanitation. The PHAST approach was proved unproductive. The program built 58 (72%) of its intended 80 demonstration VIP latrines. The intention was that District Health Officers and Village Health Assistants would stimulate households to build their own Ventilated Improved Pit (VIP) latrines, using demonstration latrines built by the project as a model. However ‘all projects have abandoned the promotion of ventilated improved pit latrines, as they are too costly. The projects supported by [the Netherlands and Sweden] now encourage households to make good pit latrines by themselves, using local materials.

**Guinea Conakry: How does improved water supply impact on the health status of villagers in Fouta Djallon (Schumacher and Albrecht 2006)**

New deep water wells have been constructed by SNAPE (Service National d'Aménagement des Points d'Eau), water committees were established and hygiene trainings performed. Additional measures to increase awareness on hygiene among the general population were applied. The prevalence of diarrhea was used as unique health indicator which was defined as “episodes of diarrhea among under-fives during the 2 weeks preceding the interview”. Treatment and control groups were compared after the new wells were used for a period of one to one and a half years. Data on episodes of diarrhea among under-fives who were treated in health institutions were also analyzed. They were not very useful, since the majority of children (90%) are usually treated at home.

Health impact in terms of the number of diarrheal episodes among under-fives was highly significant: “19.7% of the households using modern boreholes as main water source reported at least one episode of diarrhea during the previous two weeks vs. 37.6% among those using traditional sources”. Health impacts could be due to a very high level of water pollution of the traditional water points or to some unknown confounding factors. The residual prevalence of 19.7% corresponding to 5 episodes diarrhea /child/year is still very high. 78.7 % of households using a new deep well consume more than 10 liters water per capita/per day. Only 23.3% consume more than 20 liters a day (Intermediate access). There is no increase in the daily water consumption compared to pre-project conditions. However, the rate of diarrhea decreases dramatically only for household using deep well water and using more than 10 liters a day. The diarrheal prevalence is quite normal (10%) in case of consumption of 20 liters and more /per capita/per day. Even 20 liters in households using traditional water sources were not associated with a significant decrease of diarrheal disease prevalence. A correlation with lower frequency of diarrhea was found for ‘covering the stored drinking water in the house’ and ‘washing hands’ in households which were using water from a new deep well (Hygiene behavior) and for better knowledge on diarrheal diseases and ways of prevention. No correlation was found between distance to the source and diarrhea for the households reporting less than 1,000 meters to their main water source. In conclusion, it seems that in the specific Guinean context, water
availability alone is not sufficient to positively impact the diarrheal disease prevalence. The causality links between project outputs and the health impact are probably the improved water quality and (or) the improved hygiene behavior.

**Zambia: Water Sector Reform Program (Raede and Kampata 2008)**

Object of the evaluation is the ongoing development measure “Water Sector Reform Program, Zambia” (WSRP). It is implemented in three phases with an overall duration of nine years, running from 2004 till 2012 and currently in its second phase. The program is designed as a cooperation measure between technical (TC) and financial cooperation (FC). The overall objective was: “The poor population's access to safe drinking water and sanitary facilities is improved and integrated water resources management is introduced”. To reach this objective, the program used a multi-level approach including policy advice, advice on establishing the pro-poor measures, operational advice for the water supply companies, and sector coordination and planning assisting the ministry of water and sanitation. To measure the achievement of the overall objective the following indicators were phrased: (1) percentage increase of population in peri-urban areas with access to safe drinking water, (2) total count of population increase in peri-urban areas with access to improved sanitary facilities, (3) usage of funds for urban water supply and sanitation, (4) implementation of IWRM and (5) improvement of female living conditions. The achievements are the following: (1) the percentage of the peri-urban population with access to safe drinking water at socially acceptable rates is increasing, (2) an overall improvement in water accessibility compared to five years ago in favor of water kiosk, visual both for drinking water, and for household use water. (3) The access of people in peri-urban areas to improved sanitary facilities is slowly increasing, (4) an improvement in quality of life in terms of time saving in all provinces and for males and females, yet females benefit most, (5) in most cases where less water borne diseases were reported, clean water sources such as the water kiosk is used but an impact was visible in all regions and not only in program regions.

**Uganda: Interventionen zur Verbesserung der Trinkwasserversorgung in Kampala (Backes 2012)**

To improve the water supply in dense settlements in Kampala GIZ-Uganda in its program “Reform of the Urban Water and Sanitation Sector” installed 390 prepaid water meters were the inhabitants could fetch water at a reasonable price. The users of the prepaid water meters were quite satisfied with this kind of water source, except with the long waiting times for repairs. They reported that the time needed for fetching water was not more than 5 minutes. Water quality was good but in 50% of the probes the residual chlorine was too low to have a disinfecting effect. Households using water from the prepaid water meters reported less typhus and skin diseases and a 50% lower prevalence of diarrhea (during the last 8 weeks). Some hygiene promotion campaigns were reported but even with misleading messages (e.g. washing hands after eating is important). Self-reported handwashing is high. Nearly all households state that they boil their drinking water.

### 7.2 Overarching topics

#### 7.2.1 Context of projects

The importance of economic, social and environmental context factors is an important lesson from the project evaluations (compare chapter 3.2). The high level of poverty, the high population growth in rural and urban areas, and the low level of literacy (28% for women in Benin) are some constraints
which may have limited the health benefits of the analyzed WASH projects. The very poorest may be excluded from the use of improved water facilities particularly if water facilities are managed by the private sector. The cost of water in the context of project supported cost recovery systems is a typical reason for continued use of unimproved water sources for drinking after project implementation (Benin, Tanzania). The households’ willingness to pay is below the reported costs of constructing a private latrine in Tanzania.

The high population pressure on a water point may contribute to a decrease of the quality of the service level by increasing the time of queuing and increasing the risk of point of source pollution. Equally in this case, people will have to rely on other, unimproved water sources.

Women’s literacy is an important determinant of child health and particularly of the prevalence of diarrhea.

In a context of water scarcity in Yemen, reaching adequate service level for positive health impacts constitutes already a real challenge per se. Water scarcity is a factor conducive to water unreliability which is proven to have contributed to the water contamination all along the water supply chain in Yemen. The underlying mechanisms were the use of water tanks not well-managed and the release of biofilms from pipes that were empty part of the time.

Other important environmental factors observed were the geographical setting in the mountainous areas in Yemen correlated with specific water distribution challenges or the risk of salty water infiltration in aquifers in the case of sea proximity. This last phenomenon is exacerbated by the climate change and the risk of sea level rise (Red Sea). The geological profile of a region may impact the level of water quality directly by increasing e.g. the level of fluoride (Yemen and Tanzania) or other chemical contaminants. The competition for limited groundwater resources with agriculture or industry limits the water availability for human consumption and increases the risk of chemical pollution of scarce resources (Yemen).

7.2.2 Water supply infrastructures
In difficult environmental (scattered population, small settlement size etc.) and socio-economic contexts, having increased the coverage with water supply infrastructures in all projects is a major achievement even if the improvements are sometimes fairly small. “At the end of 35 years of Netherland support, the proportion of Shinyanga’s rural population in Tanzania that has access to improved water sources has risen to about 43%” (10.5% in 1992). From an epidemiological point of view, this coverage is still too low to impact positively the general community health status. Some factors like the allocation of new water points to localities with already adequate water services have slowed the rate of coverage. In Benin, 38% of realized water points had been allocated to localities which already had adequate service. Evidently, coverage in water points does not mean improved “use of safe water”. Shortcomings in training of the villagers in managing, operating and maintaining the facilities, lack of funds for replacement (In Benin, of the water points built within the last three to five years, 20% were not in use any more.), absence of water quality check etc. endanger the quality of service level.

It seems that the time savings per day for fetching water may be considerable and for instance amount to 140 hours (17.5 days) and 329 hours (41 days) per year per household in Benin. In Tanzania, the time used to fetch water has fallen substantially, by about 60%. A minority of households report time savings in Yemen. Even if economic benefits or increases in school
attendance for the girls have been difficult to establish, unspecific health benefits may be considerable and have community-level effects as well as individual effects. Women have more time to invest in socio-cultural, educational and domestic activities. These activities may directly influence the general well-being of the family (e.g. mental health), the health of children as well as of the elderly and of chronically ill patients (AIDS, TB, diabetes etc.). Furthermore, time to rest may improve resistance to infections. The frequent locomotive system impairment in Africa among rural women could be improved in the long term but is difficult to measure in an evaluation.

The construction of wells has not led to an increase in consumption of drinking water in Tanzania (water quantity); in Benin, the total water collected increased by only 7 liters per capita per day of already 30 liters consumed. In the rural project in Yemen, a semi-arid country where the water needs are extremely high, the quantity consumed is still only around 19-26 liters per capita per day (basic to intermediate access). Under this condition, the reported incidence of kidney stones related to low water consumption is not surprising.

An issue of concern in the projects is the low water quality performance: The water quality and risk factors which may lead to compromised drinking water quality are not checked systematically. There is a risk that people consume chemically (fluoride, nitrate, etc.) or microbiologically contaminated water which may particularly affect child health. In Benin, the impact of water point installation on point-of-use microbial quality is close to zero. In Yemen, scheme water does not appear to be of better quality and may in fact be worse than no scheme water. In Tanzania, two-fifths of the water users reported that unimproved water sources are still used for drinking water and probably mixed with improved drinking water at the household level. From the Yemen project it cannot be excluded that in some specific contexts pipe water could even be more contaminated than water from other sources and a matter of health concern. Water supply schemes can even bring their own health hazard. The majority of users does not boil water before drinking and even may reduce and / or stop boiling practices after source rehabilitation or after the implementation of a new water point.

### 7.2.3 Sanitation programs and hygiene training

In Benin, “the impact analysis did not find evidence for an effective integrated water supply, sanitation and hygiene-promotion approach partly explained by institutional factors” (Ministry of Foreign Affairs (Netherlands) 2011). This assertion can be extrapolated to the other projects. It is not surprising that the sanitation coverage is far behind the water supply coverage. Latrine coverage in Benin is very low (4 % for the rural population in 2008). In Yemen, 35 % to 68 % of the population considered in the evaluation have a toilet (sanitation coverage data for the rural areas are hardly available). Nevertheless, the use of toilets, if existing, is very low. In Tanzania, most households use simple pit latrines made of local materials with probably low health impacts. Moreover, the lack of cleaning and maintenance partially due to the unavailability of water are the biggest problems in increasing the use of public latrines.

Hygiene training on hand washing practices in Tanzania using the PHAST method as integral part of the approach to rural water supply did not seem to have any significant impact on behavior. (The details of the PHAST method are described in chapter 4.1.) The PHAST method may include both construction and management of new physical facilities as well as adoption of safer individual and collective behavior. The activity was possibly of substandard quality and based on the erroneous
assumption that knowledge would spread and conduce to behavior change. Probably unskilled community-based associations were contracted by the project for this purpose as District Health Departments generally lacked the capacity to facilitate PHAST. One of the major constraints identified during this early PHAST experience was poor follow-up by district council staff, due partly to transport constraints and partly to inadequate training at that level.

The participation rate in Tanzania was probably too low to reach any effect. (No effect on hand washing.) The survey results surprisingly show that only about a third of the Water User Groups reported to have received PHAST training (compare deficient implementation chapter 3.2). Moreover, this approach needs a lot of time, is expensive, and has to be repeated. Evidence of change in hygienic practices is limited in rural Yemen even if households from water scheme villages have better awareness of sanitation and hygiene practices than no scheme villages. In Benin, safe hygienic behavior is not widespread and did not change much over the period studied.

It seems that the quality, frequency and regularity of hygiene training or awareness campaigns are often insufficient for reaching the entire target group (rural Yemen). Only a third of the Water User Groups reported to have received hygiene training. Another problem is the very low participation rates in hygiene trainings due to neglected planning of activities and/or shortage of financial or human resources. It would be important to assess the cost-effectiveness of hygiene campaigns or trainings like PHAST or other methods: The results would be probably rather disappointing in most of the settings. It is not worth looking for health impacts if process indicators show an unsuccessful approach (low rate of participation, etc.); if people have no access to water (less than 20 l/capita/day) or no access to sanitation. Settings approaches seem to have some advantages but are no panacea. The limitation to a specific setting implies the possibility of more intensive and repetitive action and limited but very visible investment as in school water and sanitation and behavior change of school children and their teachers. In Benin, the Ministry of Health does not give priority to hygiene and sanitation and scarce resources are more likely to go to new water installations. There is a real need for harmonization of approaches between the government and non-state actors (some NGOs subsidize latrines, government does not etc.). There is often a lack of coordination between technical social and institutional aspects of the approaches.

7.2.4 Monitoring, evaluation, and indicators
The lack of an adequate baseline analysis, monitoring, record keeping and archiving (in projects, water institutions or health centers) has clearly hindered evaluations procedures. Capacity for data management at the local and central government levels had been improved during the project implementation in Yemen (rural) but was not maintained after project completion as the project did not succeed in institutionalizing them. Baseline surveys are often neglected and if realized seldom integrated in a professional “results-oriented monitoring and evaluation process” which permits a sound monitoring for early detection of bottlenecks, follow-up and a later assessment of impact.

Financial monitoring and monitoring of physical progress during construction of schemes or technical data are mostly available. However, in Yemen, monitoring of water access coverage is not always reliable and the sanitation coverage data for the rural areas are hardly available. In Benin, “The current rural water supply and sanitation strategy as well as the donor support provided are not adequately based on empirical evidence”, no data on groundwater availability was found and
hygiene promotion is not systematically monitored. Monitoring is neglected in Tanzania. No regular bacteriological checking or other monitoring has taken place etc.

The mostly used non-health indicators are identical for most evaluations being the “coverage rate for water and sanitation”. In addition, the evaluation of Benin focuses on the use of sanitation facilities.

The evaluation in Tanzania relies on tests for Coliform bacteria (total Coliforms) for testing the water quality which is not a suitable indicator (see box in 6.3.3).

Subjective assessments often differ from more objective measures. Measuring the daily water consumption may be challenging as large deviations were observed between self-reported water use, water meter readings and recall information on water purchases from trucks (urban Yemen). Uses of the “bill of payment for water” for calculating the daily water consumption is difficult as secondary sources (rain water, vendors) are excluded. In Yemen, data from the water utilities were unreliable. The self-reported amounts paid for water can be biased as all other self-reported data.

There should be a consistent and complete conceptual chain from activities (not only of the specific project but including also other interventions that could influence the outputs and effects) to outputs to effects to impact (health). This should consider scope (“quantity”) of the intervention(s), as well as the quality of services at the outset of the project and its change after completion of the project. Indicators at the different levels (starting with the activities — scope and quality...) should be selected from the list of indicators provided in chapter 6, depending on the project setting and on what data is already available. Frequent control of the proximate indicators (monitoring) and less frequent but regular check of the distant indicators.

7.2.5 Health impact analysis

The only health indicator used by most studies is diarrhea. The standard definition of diarrhea prevalence as it is used in reference studies has been modified. For instance, in one evaluation the reference unit for a diarrhea episode is not the child (diarrhea episodes per child during a given laps of time) but “the household with a case of diarrhea among adults or children”. The recall period is up to one year compared to the standard of several days. To increase its power (higher sensitivity and sensibility), the indicator of diarrheal disease should normally focus on children younger than five years of age. This is the case in only one evaluation. It is evident that this makes comparisons with data of other (state of the art) studies impossible and casts doubt on the scientific value of the results.

In the context of general HIE, diarrhea in children younger than 5 would be appropriate. They are the population at highest risk leading to an indicator with higher sensitivity and sensibility than diarrhea in the general population, except sometimes in the case of large epidemics of cholera, dysentery, or typhoid.

In several evaluations questions were asked about diseases and symptoms that need specific knowledge and are not normally used in household surveys. Precise definitions of diseases like cholera, typhoid, malaria, hepatitis, intestinal worms, or schistosomiasis cannot be easily explained to family members. Thus their answers may be approximate and dependent on their subjective medical knowledge which is often culturally influenced. Consequently, a lack of specificity and reliability characterizes these indicators. Even if the “incidence of diseases” is used as indicator at a
health facility, one must be sure that disease definitions are well understood and the same for survey’s team and health staff. Moreover, cholera, typhoid, giardia, dysentery, amoebiasis, malaria, hepatitis, intestinal worms and schistosomiasis can only be diagnosed through laboratory blood, urine or stool tests.

Symptoms of diseases are largely used with weak specificity. In urban Yemen, the use of 18 health indicators may significantly have confused the interviewed person as it seems that perceived disease frequencies are somewhat small. A small number of well thought indicators may be considered more useful. Selecting fewer indicators will allow to invest more resources in ensuring the quality of the survey, for instance in careful training of interviewers and pre-test of questionnaires.
The study of Tanzania reports clear positive health effects. One study reports some weak positive health effects (rural Yemen). The study of Yemen (urban) reports clear negative health effects. For reported symptoms incidence during the last four weeks for treated and control households the data indicate that diarrhea, abdominal pain and vomiting occurred more frequently in the project areas, compared to the control areas. The evaluation couldn’t clearly identify the causes. In Benin no impact of improved water source on water related diseases was observed. In Guinea the incidence of diarrhea of children under five in the previous two weeks was measured. Only for users of clean modern deep water wells it was found that the higher the water consumption the lower was the risk of attracting diarrhea. For the case of Uganda it was stated that no significant influence of consuming clean water could be found.

The use of non-standard indicators for capturing health effects and insufficient application of established public health standards leads to results not comparable to other studies. Medical records are used without prior measures to assure availability and reliability of data. In urban Yemen, it seems that the data in health facilities were either unavailable or unreliable (as it is also often the case in health facilities in African context). Finally, out of all collected symptoms, only the information on diarrhea incidence has been used, since this was the most complete data for all health facilities.

WASH interventions can – if properly implemented – have a positive impact on health and there is already an extensive evidence base for the causal relationship between WASH and diarrhea (compare chapters 6.1.2; 6.2.2; 6.3.2). However, to expect a consistent magnitude of effect (a 10% reduction in diarrhea incidence? 30%? 75%) is clearly unrealistic: the health impacts of WASH interventions can be expected to vary greatly depending on very diverse factors including local disease ecology, baseline water and sanitation quality, baseline hygiene practices, and the precise
nature of the intervention.” (WSUP/SHARE 2011). However, it is important to realize that a lack of visible effect does not imply that the intervention is useless – it may equally mean that further interventions are needed to block other infection pathways, and once this is accomplished, the WASH measures can begin to show effects. Furthermore, time savings gained from bringing water and sanitation infrastructure closer to the household are often substantial, and highly valued by households.

Ex post health impact evaluation without a functioning and well-designed monitoring system is difficult to realize and often expensive. It should be carefully prepared during project implementation and envisaged only if expected to be cost-effective. A health impact assessment is cost efficient if the expenses for it are in a reasonable relation to the knowledge created. To be cost effective, HIE should enable to analyze and document the specific causal chains for health impact of the analyzed project. If the health impact is highly predictable as the necessary WASH preconditions for health impacts are realized to a large extent in the target population, a HIE will only confirm established knowledge. The cost-effectiveness would be lower in such a case than if new knowledge is expected to be created. If the WASH conditions necessary for positive health effects (project outputs or intermediate outcomes of a project) are not realized, expenses for HIE should be better invested in improving the level of water and sanitation access.

7.2.6 Challenges in urban settings

In 2012, the BMZ proposed a check-list for improved effectiveness in the water and sanitation sector. As WASH interventions in the future should focus more on peri-urban and urban areas, some specific challenges have been summarized in this chapter. Health risks due to poor WASH access are higher for the poor than for other socio-economic classes because of higher vulnerability. This is why the probability of positive health effects increases with proper selection of WASH projects concerning their pro poor orientation and their performance concerning first-line targets as e.g. improved access to and utilization of water and sanitation facilities, improved behavior etc. Population in urban settings is growing worldwide challenging the WASH sector. New infrastructure development projects usually provide sanitation services to up to 60-70% of the urban population, focusing on those residing in strategic residential areas. Investing in sanitation in informal settings should reduce the “gap” between inappropriate on-site sanitation (e.g. absorption pits) and the shortcomings of expensive conventional centralized sewerage collection and treatment systems.

Urban settings are prone to epidemics of diarrheal diseases (outbreaks of cholera), malaria, dengue and others, non-infectious diseases like diabetes and heart diseases. Especially in informal urban settings, delivery and management of basic infrastructure services (including institutionalization of services, O&M, replacement of equipment, etc.) impact directly on the health status of the population by protecting them from a microbiologically and chemically contaminated environment. The generally higher exposure to specific risks can be reasonably assumed. The lower cost of providing health care (and other basic services) to a densely populated area compared to providing it to the typical rural settings is evident and leads to a relevant potential for implementing efficient interventions at relatively lower cost than in a rural context.

Statistics show that the burden of infectious diseases is very high in informal settings compared to other settings with access to most of the public services. In Bujumbura 2013, the rate of diarrheal diseases in informal settings is 1.5 to 3 time higher than in other settings with better living conditions.
and higher SE level. However, the poor are often neglected as they cannot pay for WASH. “Because the poorest urban households typically spend more than 90 percent of their household budget on food, the money they spend on water is sacrificed from their food budget” (Cairncross and Kinnear 1992).

For project sustainability in the urban setting several measures have to be deployed. First alliances with local governments and other partners to coordinate the up-grading of informal urban settings in the WASH sectors (coherence and consistency) have to be created as well as synergies for financing and finally emphasize the good urban governance. To ensure sustainability for upgrading, WASH program should be integrated in a “global up-grading plan” including institutional and legal issues (e.g. land tenure rights), low-income housing, and municipal infrastructure. The whole sanitation chain for the entire city area has to be considered to avoid dramatic health consequences of polluted stagnant waters following blockages of sewages, flushed toilets and accumulation of solid waste inside the city. Last but not least project implementation and operation need constant monitoring.

**Environmental issues:** Storm waters drainages must be carefully addressed because of the risk of erosion (damage to housing, death), and the risk of widespread contamination of the environment. Uncontrolled discharge of liquid sludge into the environment poses serious health risks and may cause pollution of groundwater and surface water bodies. Possible solutions include on-site infiltration, rain water retention for domestic use, preservation of natural drains and separate drainage for rain water.

**Increase affordability of improved sanitation:** Low-cost, locally adapted and efficient technologies like “simplified sewerage-systems”, “shared septic tank systems”, emptying by service providers etc. may increase accessibility and ensure a necessary “minimal” coverage (estimated to be around 75% of a given target population) for consistent health improvements. Coverage means homogeneity of intervention on the ground leading to equal accessibility to specific services or benefits for the whole target population; interventions following a patch work model should be avoided. Poor households lack often the financial ability to afford improved sanitation technology. Specific mechanisms should be developed for budgeting of hardware, software and O&M as for instance micro credits for sanitation through sanitation shops and the mobilization of local financing for the poor. If investment costs may be financed by public or private development agencies, active participation of the population is often necessary for filling the budget gap for managing the facilities (O&M). For population motivation participatory planning based on informed choice is important. Building capacity for maintenance of public infrastructure assets should be taken into account.

If there is a lack of space to construct household toilets due to overcrowding or land ownership constraints, the implementation of community and mobile sanitation systems with downstream processing run by the private sector may be a solution to make markets work for the poor (public private partnerships- PPPs). Professional sanitation marketing and social marketing in urban setting have budget consequences that are not always sufficiently considered.
7.3 Integrative analysis of the projects and conclusions

In this chapter the described projects are summarized and evaluated according to the conceptual models developed in chapter 3. Therefore we analyze the projects according to the following:

- **WASH interventions points**: which pathogen transmission routes were tackled in the project by implementing sanitation, source water, water point-of-use or hygiene promotion (see chapter 3.1).
- **Implementation**: which hardware and which software was used, how it was implemented, whether the intervention functionality and the change in behavioral determinants was proved (see chapter 3.2).
- **Dealing with context aspects**: how should different aspects of the context be considered (chapter 3.2 and 7.2.1)
- **Behavior change**: how was behavior change implemented and with which success (chapter 3.2 and 4)
- **Results, indicators, and monitoring**: which indicators were used for which WASH theme; which results were aimed to achieve and which results should be aimed at in our understanding (chapter 3.3, see figures 3.3 and 3.4); and how should a monitoring be conducted.

After each discussion first recommendations are drawn (recommendation R1 to R10).

**WASH intervention points:**

When concentrating on source water interventions many other pathogen transmission routes are not interrupted (see Figure 3.1). This means that in this case one cannot expect to have a big impact on health. Guinea: water availability alone is not sufficient to positively impact the diarrheal disease prevalence. Nearly all projects concentrate on source water interventions meaning that they focus on the provision of access to safe water, herewith neglecting somehow that in most cases the drinking water has to be collected, transported, stored and drunk with specific vessels (see chap. 6.3.2) - all these activities are prone to foster contamination: Benin: 30-40% of storage containers are contaminated; Yemen/urban: contamination through mixing water sources, storage tanks; water handling when drinking; Yemen/rural: contamination in storage tanks. With Water-POU interventions this contamination can be overcome and these interventions have been demonstrated to have health impact (see chap. 6.3.1).

**R1: To prevent re-contamination of drinking water which is collected outside the house, behavior change interventions focusing on safe collection, transport, storage and drinking and/or water-POU applications have to be additionally applied. Sanitary inspections should be applied to assess water storage at the household level, which should be combined with behavior change for hygiene issues in the households.**

**Hardware implementation /intervention functionality:**

In many projects a rather big percentage of the improved water sources still show high contamination (Tanzania: 75%; Yemen/urban: 20-50% of piped water; Yemen/rural: some contamination in 50%). This can be due either to poor construction or, more likely, poor operation and maintenance. Some water sources reveal high concentrations of substances which were evidently not considered adequately during planning (e.g. fluoride in Tanzania; Yemen/urban: total dissolved solids; Yemen/rural: fluoride in 80% of the villages). Also frequent nonfunctioning is reported: Benin: 57% had interruptions, 20 were not in use; Yemen/rural: 15% not functioning.
R2: Continuous management and maintenance of the systems should be considered for the time after installation of infrastructure. Regular inspection and review of system management, potentially in conjunction with water quality monitoring and sanitary inspections to identify risks for public health of water sources have to be established. Results of analysis and inspections should be linked to action through a dynamic operation and maintenance program.

Software implementation /change in behavioral determinants:
All projects had a software component but implemented with several limitations: a) nearly each project developed its own software, meaning that no comparison regarding successful elements can be drawn; b) no widely used software was implemented, with the exception of PHAST in Tanzania (see chapter 7.2.3 and 4.2); c) the impact of the software, the change in behavioral determinants was not measured, if for example knowledge was targeted to be changed then change in knowledge should be measured; d) no baseline analysis of behavioral determinants was conducted which should be the evidence for the development of the software.

Therefore it is not surprising that the software mainly shows nearly no effects: Benin: no significant effect of hygiene interventions; Tanzania: knowledge of good hygiene reported; Zambia: no application of hygiene promotion reported; Guinea Conakry: hygiene training and additional measures to increase awareness on hygiene; Yemen/rural: limited number of households report recalling hygiene awareness campaigns; Uganda: misleading messages.

R3: The applied software should be evidence based using a standardized survey instrument which reveals data on behavioral determinants and can be used in a baseline and post-intervention survey (with appropriate control areas, e.g. a BAC design).

Dealing with context aspects:
From many projects heavy influences of context is reported (compare chapter 7.2.1): Tanzania: population growth, accelerating urbanization, water scarcity, water governance; Benin: institutional factors undermining water supply; Yemen/rural: capacity and consistent commitment at central government level, local conflicts; Zambia: regulation and sector coordination.

These context factors are reported to be mainly recognized during project run time or even after project end. The influences of these factors on project success should be reported in detail and condensed in a project collection where it can serve project planners as template about which context factors they should reflect. A checklist about possible contextual influences should be completed before beginning the project and it should include ways on how to deal with these influences.

R4: Develop a checklist containing possible influences at project level from environmental, cultural, social, economic, and legal context and ways on how to deal with them.

Behavior change:
From nearly all projects incomplete behavior change is reported. A rather big proportion of the households uses other than improved water sources (Tanzania: 40%; Benin: 37% - 49%; Zambia: 70%-83% not using water kiosks, 11-30% use unprotected wells; Yemen/urban: 25% main water source is from water vendors) and some proportions of the population simply refuse to use the improved sources. A thorough analysis of behavioral determinants could have helped. If for example the analysis reveals that a majority of potential users perceive the way to the improved well as too long and therefore do not use it then persuasion on the perceived distance should be part of the software to be implemented. Not the real distance but the perceived distance (in terms of time and effort) steers the behavior and this perception can be altered with behavior change interventions.
R5: An evidence-based behavior change intervention should accompany the installation of improved water sources to secure a high usage and that a high proportion of the population uses it.

Results, indicators, and monitoring:
The main targeted outcome of all projects is improved health of the population especially of children below the age of five. The indicator used is mainly the prevalence in water related diseases. Taking into account the multitude of transmission routes of pathogens (see Figure 3.1) and the many ways in which project components can be implemented inadequately (see Figure 3.2) it is plausible that a project could achieve its objectives yet still have no significant impact on health. Therefore it is advisable to monitor indicators for “lower level” results / outcomes as depicted in Figure 3.4 and leave the corroboration of the health impact of these lower level outcomes to scientific investigation.

R6: Use lower level results for evaluation of a project, e.g. continued use. As results of the projects other than health outcomes could be targeted: consumption of safe water; use of clean latrines; handwashing at key times with soap; consumption of safe food. Indicators as proposed in chapters 6.1.4; 6.2.4; 6.3.4 should be used.

From many projects benefits other than health outcomes, especially time savings are reported. Tanzania: 60% reduction in time women spend fetching water; Benin: time savings 23-54 minutes; Zambia: time savings men 25 min., women 41 min.; Yemen/rural: introduction of house connections has led to considerable time savings. It is not clear whether these outcomes were targets of the projects or only side effects. If reducing the time for fetching water would be targeted then specific measures should be implemented, and collection time would be an appropriate outcome indicator.

R7: The principal impacts of source water interventions are in time savings rather than direct health impacts (i.e. ...). To maximize time savings, projects should target populations facing long water collection times. Project planners should recognize that such interventions will not necessarily yield direct health gains.

It has to be stated that in our understanding access /coverage is not an outcome but rather an output because access does not mean use (see Inauen et al., 2013, for the case of access to but not use of different arsenic-free water sources in Bangladesh). Zambia: access to safe drinking water in peri-urban areas. Between access to sanitation and actual and proper use there is a large difference (see case study Benin), this difference being influenced by distance, safety, cleanliness, and maintenance.

R8: Access / coverage should not be treated as an outcome but as an output. Actual use and behavior as well as the actual functioning and the safety of these systems (e.g. of drinking water quality) should be used as outcome indicators.

Monitoring and evaluation is not employed in a standardized way. Each project plans its evaluation as it seems convenient. In chapter 7.2.6 we stated that the use of non-standard indicators for capturing health effects and insufficient application of established public health standards leads to results not comparable to other studies. There should be a standardized regular monitoring scheme to make the projects comparable. We distinguish between routine monitoring of inputs (internal) and outputs and evaluations (external). We suggest to implement a standardized external evaluation every 12 months as this is a reasonable time period to scrutinize project progress and that project hindrances can be detected and measures be applied. A standardized survey tool should be developed and tested for projects tackling WASH.

R9: Projects should be monitored by applying a standardized survey tool annually.
8 Designing WaSH projects

8.1 Focus on water, sanitation or hygiene?

**Water:** The analyzed projects seem to prove that the potential for health impact depends very much on the water quality at the point of consumption rather than water quantity or collection time. Several projects invested in water infrastructure which in the end delivered water which was microbiologically or chemically unsafe at the point of consumption. Projects having a water supply component should plan to ensure water safety up at the point of consumption as well as sufficient quantity. However, this is not achieved simply by monitoring indicators such as *E. coli*. Rather a holistic approach to risk identification and management, such as the **Water Safety Plan (WSP)** approach, should be an integral part of planning and implementing water supply interventions. There is reasonably strong evidence from a range of literature sources that community water supply interventions in developing countries, taken alone, may have only a very small impact on water quality and health, and household water interventions have a somewhat larger positive health impact in most – but not all – cases. One reason is recontamination between water source and water use. In contrast, it has been shown that water **treatment interventions at point of use** (chlorine, boiling, solar disinfection, filters) have a high impact on water quality and health. This means that a water supply intervention should always be accompanied by behavior change strategies which assure exclusive use of safe water sources, safe transportation, storage and handling of the drinking water. Taking into account the many behaviors to be changed it seems reasonable to include the promotion of point-of-use water treatment systems in settings where delivering safe water to the households cannot be ensured: even if the drinking water is delivered in-house, in developing countries this can mean that the quality of this water is non-reliable meaning that also in this comfortable situation the use of a point-of-use system may be indicated until continuous safe supply can be ascertained.

Water supply interventions have had marked success in **reducing collection time**. Although this may not translate to health gains, such time savings are often highly valued, and do contribute towards realization of the human right to water. Where programs focus on water supply, they should explicitly target those who must travel long distances to collect water, and monitor time or distance indicators even if no health gains are realized.

**Sanitation:** The theoretical argument for a higher health impact of sanitation (in comparison to water supply) seems to be confirmed by first empirical studies on health (see chapters 6.1.1 and 6.2.1). However, the quality of these rather few scientific studies is much lower than for water supply and treatment. Where sanitation is poor, WASH interventions should **start with a strategy which eliminates open defecation** before scaling-up the “sanitation ladder” e.g. first shifting from open defecation to fixed point defecation. Later people are proposed to progressively use better quality facilities. Provision of sanitary facilities only does not necessarily lead to increased coverage and use. For this reason the **whole system of sanitation implementation has to be considered:** good preparation, strong institutions for effective O&M, empowerment of all stakeholders, access to sanitation infrastructures, access to water, sanitation promotion, hygiene education, behavior change and favorable environmental and socio-economic conditions, school sanitation etc. A frequent reason for failure is that a part of the whole system becomes more important than the system itself, e.g. focus on infrastructures without taking into consideration operational maintenance concepts, or behavior change - or the contrary - or sanitation access without sufficient water access.
etc. Water scarcity leads to lack of maintenance, low levels of latrine usage or abandoned latrines and increased health risks (Klasen et al., 2011).

**Hygiene:** There is strong evidence that handwashing with soap after defecation has large health impacts in a wide variety of settings. Promotion of handwashing with soap is a highly cost-effective intervention if the main objective is to reduce diarrheal disease. However, such interventions should be firmly based in an understanding of behavioral determinants. There is emerging evidence that food hygiene is critical for control of diarrheal disease. Limited evidence suggests that handwashing around food handling events is strongly linked with disease reduction, but more work is needed to identify other effective interventions for food hygiene, supporting the approach to first assess relevance of transmission routes relevant in the context concerned.

**Alone or together?** Surprisingly, studies that have analyzed the combined impact of various components of WASH have not found complementarities between different interventions. Reasons for this result could be the fact that multiple interventions are very ambitious and may result in an overall lack of focus or lack of sufficient attention paid to the single components. Therefore, the surprising findings of this rather small number of studies should not discourage comprehensive approaches, but one conclusion is that in such ambitious projects it is important to ensure that each component needs sufficient resources to reach its targets. Where this is not affordable, a prior assessment of the contribution of the different pathways to the overall burden of disease is important for setting priorities among the possible interventions.

**Summarizing, we recommend that**

(a) Organizations should begin the projects with a baseline survey for an assessment of the local relevance of the different exposure pathways, setting priorities for interventions and testing those against their economic feasibility as well as requirements for their acceptance on the basis of socio-psychological and cultural aspects.

(b) The focus should be more on projects with the major objective to improve sanitation in combination with hygiene (also food hygiene).

(c) For water, sanitation and hygiene interventions, both behavioral change - and the utilization of evidence-based behavior change techniques – and infrastructure should be targeted: water supply is not only infrastructure provision and hygiene is not only behavioral change. Sustainability should be addressed in projects, making provisions for continuous safe operation and maintenance of installed infrastructure.

**8.2 Focus on settings?**
Sanitation in urban settings poses particular challenges. Poor sanitation can easily lead to spread of disease in dense settings such as urban slums and fringes. However, urban settings are also positive for sanitation in that demand for sanitation may be higher due to the lack of alternatives (e.g. fields and forests), supply chains and communication networks are more readily established, and capacity to pay may be higher than in rural areas.

To our knowledge there is only some evidence that working in school settings has an impact on child health. There is no evidence about a transfer of school health promotion activities to households or communities and without additional activities in households and communities we do not see why
there should be an impact. There is also some evidence that working in health centers has an impact on health especially working with antenatal care where evidence shows that it also has effects on households (Wood et al. 2012) and there is some evidence that working in refugee camps is effective (Cronin et al. 2008, 2009; Roberts et al. 2001). With regard to markets, transport centers, prisons, or workplaces to our knowledge there is no scientific evidence about health impacts. Summing up it seems to be useful to focus on specific settings like schools and health care centers but more evidence is needed here.

8.3 How should the projects be conducted?

It is worthwhile to invest in solid project preparation to understand the specific socio-economic, cultural and environmental context and the actual motivations behind the sanitation behavior of different social groups (KfW Water Symposium 2009) to avoid the risk of weak results (or even negative health impacts). Sound baseline analysis could identify which pathways are likely to dominate in disease transmission, and allow targeting of specific pathways for greater effectiveness. In the preparation phase, the target group baseline analysis should be improved and suitable control areas should be determined and also surveyed. Hygiene behavior should be analyzed more deeply than is the case in most projects. The psychological factors that sustain a specific behavior should be explored (RANAS, FOAM, etc.) to find out the factors that are relevant for change before designing the intervention.

Considering the many not properly functioning installations (which are an old and well-known problem) we have once more to emphasize the importance of the controlling of the hardware implementation, in particular the continuous operation and maintenance. Clear plans should be made for operation and maintenance, including supply of spare parts and retraining as caretakers depart, before any construction begins. There seems to be a need for a standardized controlling and maintenance procedure. If there is already such a procedure then the question remains why implementers do not adhere.

For drinking-water supply, developing a Water Safety Plan together with the local stakeholders and potential operators of the supply system, can be an excellent way (i) to prioritize measures controlling drinking-water safety according to expected water quality impact in relation to costs; (ii) to develop a sound basis justifying investments for upgrading the system; (iii) to create ownership and motivation for continued maintenance and operation after the project as well as (iv) to create a platform for periodic review of the management system. WSP development – from catchment to consumer, i.e. including the point of use – is therefore recommended as a basis for planning or point of departure for interventions targeting drinking-water.

Considering the weak and unsystematic implementation of WASH software we recommend to also standardize this procedure and to use an evidence-based behavior change approach (see subsequent section on behavior change approaches).

Interventions on the meso- and macro level are often essential for ensuring sustainability of change. Without a strong political will and commitment and strong institutions, WASH projects will hardly ever reach the goal of high or even universal coverage. A high coverage is a necessary precondition for measurable health impact. Projects should invest in advocacy for increasing political awareness or only invest under pre-conditions of political and institutional reforms (selective investment). Lack of clearly defined responsibilities in WASH policy at the central level may hinder project implementation. Projects should help to resolve the problems of coordination in the WASH sector between ministries (Water, Environment, Health, Education and others) and create synergies to
avoid overlapping of responsibilities and negative competition. Where this appears hopeless, it may be important to check whether a focus on local community ownership is promising in spite of the lack of support from the meso- and macro level.

The weak anticipatory attention to context factors was mentioned many times in this report. There is no scientific evidence about how these factors influence the outcomes of WASH projects and there seems to be none in the foreseeable future. Nevertheless, for the sake of organizational learning we recommend to develop a standardized reporting about the project influencing factors and a deep elaboration on these factors before project beginning.

8.4 How should the projects be monitored and evaluated?

In chapter 3.3 we stated that programs and projects which target health improvements have to make a strategic decision as to which result in this framework could be set as the objective, for which the project/program would be held responsible. Indicators should be established for both the objective and the proximate results targeted. The minimum is to conduct cross-sectional surveys before and after an intervention (baseline and post-intervention survey), with a control group (‘Before and After Control’ (BAC) study). With this design, a Difference in Differences (DID) analysis can be executed to see how much of the change can be attributed to the intervention, and how much is due to general trends in the population. If the project is lasting for more than 1 year it is advisable to perform in-between surveys annually to have data about the progress of the project and to be able to react to reasons of blockages. There could be lower-level monitoring that is more or less continuous which could be analyzed by the country offices. We recommend that agencies could request semi-annual reports, which should include result level monitoring (e.g. outputs).

If health impact assessments are proposed, baseline and follow-up surveys should be planned, in both intervention areas and control areas where no comparable intervention is expected over the project period. Health impact assessments should be designed by epidemiologists, in order to reach an appropriate sample size. Objective measures of health outcomes are preferred, and further work may validate emerging indicators such as weight-for-age Z-scores. However, self-reported diarrheal disease is the most widely used indicator, and will probably be used for the majority of impact studies. Careful design and training of field survey teams are crucial to ensure that disease measures are valid: in particular, recall periods should be short—not more than a week.

In large or small projects, the primary aim of monitoring should be of the highest result within the project domain (see figure 3.4). In many cases these will be the proximate causes of health impacts, namely management and use of safe drinking water and hygienic sanitation systems, effective handwashing practices, and possibly hygienic management of foods. These are all behaviors, and should be monitored using the most efficient available valid indicators, as reviewed in chapter 6, and summarized in table 8.4. Outputs such as numbers of systems built, or population with ‘access’ to facilities should also be monitored, but these alone are not sufficient: monitoring should additionally measure actual management and use.
Table 8.4: Summary of WASH indicators

<table>
<thead>
<tr>
<th>Indicators for sanitation</th>
<th>Indicators for hygiene</th>
<th>Indicators for water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of sanitation facility used</td>
<td>Self-reported HWWS after defecation</td>
<td>Type of drinking water source</td>
</tr>
<tr>
<td>Fecal sludge management systems</td>
<td>Proxy: Observed presence of soap by latrine or in yard</td>
<td>Water quality: fecal indicator bacteria</td>
</tr>
<tr>
<td>Is the sanitation facility clean?</td>
<td>Proxy: Spontaneous use of soap when asked to demonstrate handwashing</td>
<td>Water quality: residual chlorine</td>
</tr>
<tr>
<td>Management of child feces</td>
<td>Visual observation of children’s finger pads</td>
<td>Water quality: geogenic chemicals</td>
</tr>
<tr>
<td>Open Defecation Free status</td>
<td>Observed HWWS after defecation (structured observation)</td>
<td>Water management: Water Safety Plan development and periodic revision, reaching from source to point of use</td>
</tr>
<tr>
<td></td>
<td>Observed HWWS before food preparation (structured observation)</td>
<td>Water management: Sanitary Inspection score</td>
</tr>
<tr>
<td></td>
<td>Self-reported HWWS before feeding a child</td>
<td>Water management: household water storage</td>
</tr>
</tbody>
</table>

WASH projects may have important impacts other than reduction in disease. The human rights to water and sanitation specify a number of normative criteria which could also be monitored in relation to use of adequate water and sanitation (see Annex 2.4). Among these, accessibility is important: improvements in access to water supply and sanitation have demonstrated significant time savings which can have important indirect impacts on physical and financial health, but would not necessarily be captured in a health impact assessment.

Additionally we recommend conducting a pretest of hardware/software strategies before going at scale with any WASH activities. It would be extremely expensive and annoying for the population when the massively implemented hardware and software has to be revised. A pretest with small samples where different combinations of hardware/software are tested against a control will reveal the most successful combination to be used for the implementation at scale. The whole procedure is displayed in figure 8.4.
8.5 Which behavior change strategy (software) should be used?
As elaborated in chapter 4.6 and in accordance with (Keipp 2012) we highly recommend to use an evidence-based psychological approach containing environmental, social, and cultural factors to understand and conduct behavior change systematically. The baseline survey would include the measurement of the behavioral determinants and by calculating differences in these determinants between performers and non-performers of a new behavior (or of a similar behavior if nobody performs it, e.g. boiling instead of solar water disinfection) the behavior change strategies would be selected according to the RANAS model. In the recommended pretest the functioning and success of different behavior change strategies would be tested. After going at scale with the most successful strategy the reach and perception of this strategy in the whole population would be revealed in follow-up surveys.

8.6 How much will the recommended procedure cost?
Depending on local wages a representative household survey containing about 800 households and including realization in the field, data processing and analysis, and reporting will cost between EUR 50-100’000. These expenses will incur once a year (recommended every 12 months) depending on how the project is structured. Calculating that 10% of the total project costs which might be EUR 1 - 10 million yearly should be used for monitoring and evaluation (M&E) then these costs should be feasible in this context and absolutely justified considering the high investments. These costs seem also reasonable particularly when the recommended procedure assures project success which can be documented with hard facts. However, these surveys are not the only M&E cost – this is the external evaluation component which should be complemented by a robust internal monitoring system, responsible for tracking inputs and outputs.
8.7 Which scientific investigations are needed?

Table 7.4 gives an overview of the research evidence available for various WASH interventions (first row) on various outcomes (first column) along the pathogen transmission pathway (see Figure 3.1). Dark grey boxes indicate strong evidence available, i.e. several high quality studies available; light grey indicates weak evidence, i.e. several studies but with difficulties in establishing causal inference or very few studies; white boxes indicate no evidence available. The signs indicate whether a certain intervention has shown a strong positive impact (++) , a weak positive impact (+), or no impact (0) on the desired outcome variable. The magnitude of impacts has already been discussed in chapter 6 and 7.2. Table 7.4 further highlights the knowledge gaps within the WASH sector.
## Table 7.4: Research Evidence and Gaps on WASH

<table>
<thead>
<tr>
<th>Impact of...</th>
<th>Water Supply</th>
<th>Water Treatment (POU)</th>
<th>Sanitation</th>
<th>Hand-Washing</th>
<th>Food Protection</th>
<th>Water Handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health (Diarrhea/Stunting)</td>
<td>0/+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Water Quality</td>
<td>0/+</td>
<td>++</td>
<td></td>
<td></td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Food Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware: Functioning</td>
<td>0/+</td>
<td>0/+</td>
<td>0/+</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Behavior: Sustainable Use/Application</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Notes:** Dark grey: strong evidence (several studies with high quality methods); light grey: weak evidence (several studies but with lower scientific standards or few studies); white: no evidence; ++: strong positive impact, +: weak positive impact; 0: no impact.

Whereas studies have extensively analyzed water supply and water treatment interventions, and increasingly data on handwashing are available, much less evidence exists for sanitation. Moreover, the impact of WASH on food (and finger) contamination in developing countries has been almost completely neglected, which is, however, also an important transmission pathway for improved health (see Figure 3.1). The impact of food hygiene interventions (such as reheating foods) are only recently been studied (Touré, Coulibaly et al. 2013), even though studies have indicated that up to 70% of diarrhea disease might be caused by contaminated food.

Moreover, whereas studies on water and sanitation supply have focused on hardware outcomes, hygiene interventions have mostly been analyzed from a behavioral change perspective. Both perspectives are important to understand for all types of interventions. Contextual studies are almost completely missing, except some first evidence on water and sanitation supply in the rural and urban context, and water and sanitation in school settings. However, none of the studies would allow a conclusion about most effective targeting of water and sanitation interventions to specific groups or locations; apart from the fact that unimproved water and sanitation disproportionately affects the health of children, and sanitation interventions are more effective in urban settings. Last, none of the studied interventions started with an analysis of the relative importance of different infection pathways in the studied population, which could be the major reason why the reviewed studies, conducted in various settings, sometimes come to different conclusions with regard to the effectiveness of the studied WASH interventions.

An important recommendation, as mentioned above, therefore is to base interventions on such an analysis, targeting the identification of the locally most relevant pathways for waterborne disease – in most cases probably from infections. WHO proposed a useful concept in the 2004 GDWQ, i.e. of first defining a health-based target in terms of a maximum acceptable number of DALYs caused by water and then identifying the contribution of the different pathways to the society’s disease burden.
as a basis for setting priorities. The challenge, however, lies in the methodology for quantifying those pathways. As outlined in section 3.1 spot-check observations could be a solution for this task.
9 References


DFID (2012). Water, Sanitation and Hygiene Portfolio Review.


GIZ (2012). A definition of access and operationalization for German Development Cooperation access targets (QVZ) for Sub-Saharan Africa.


